THE ENGINEER

AUGUST 18, 1961

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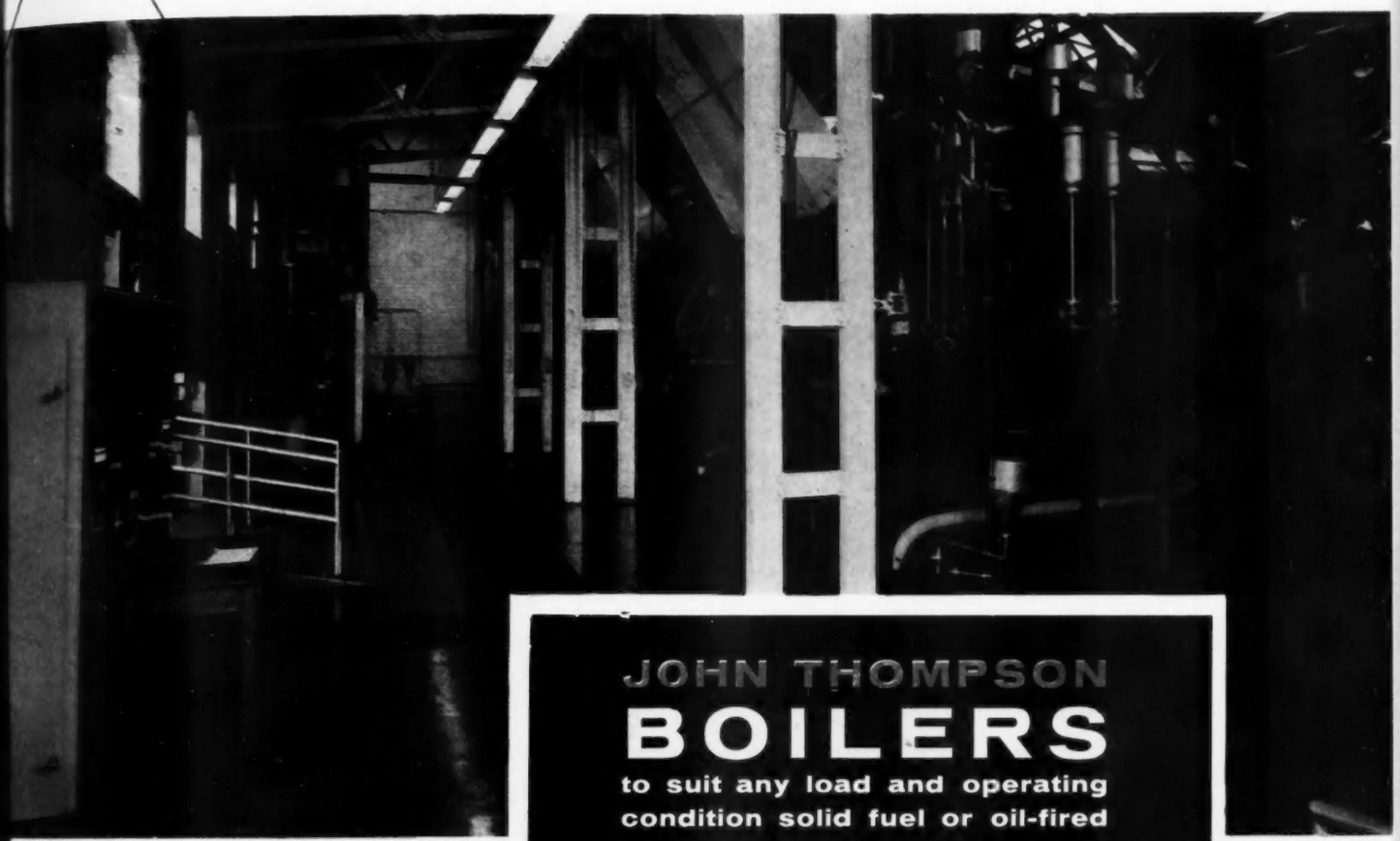

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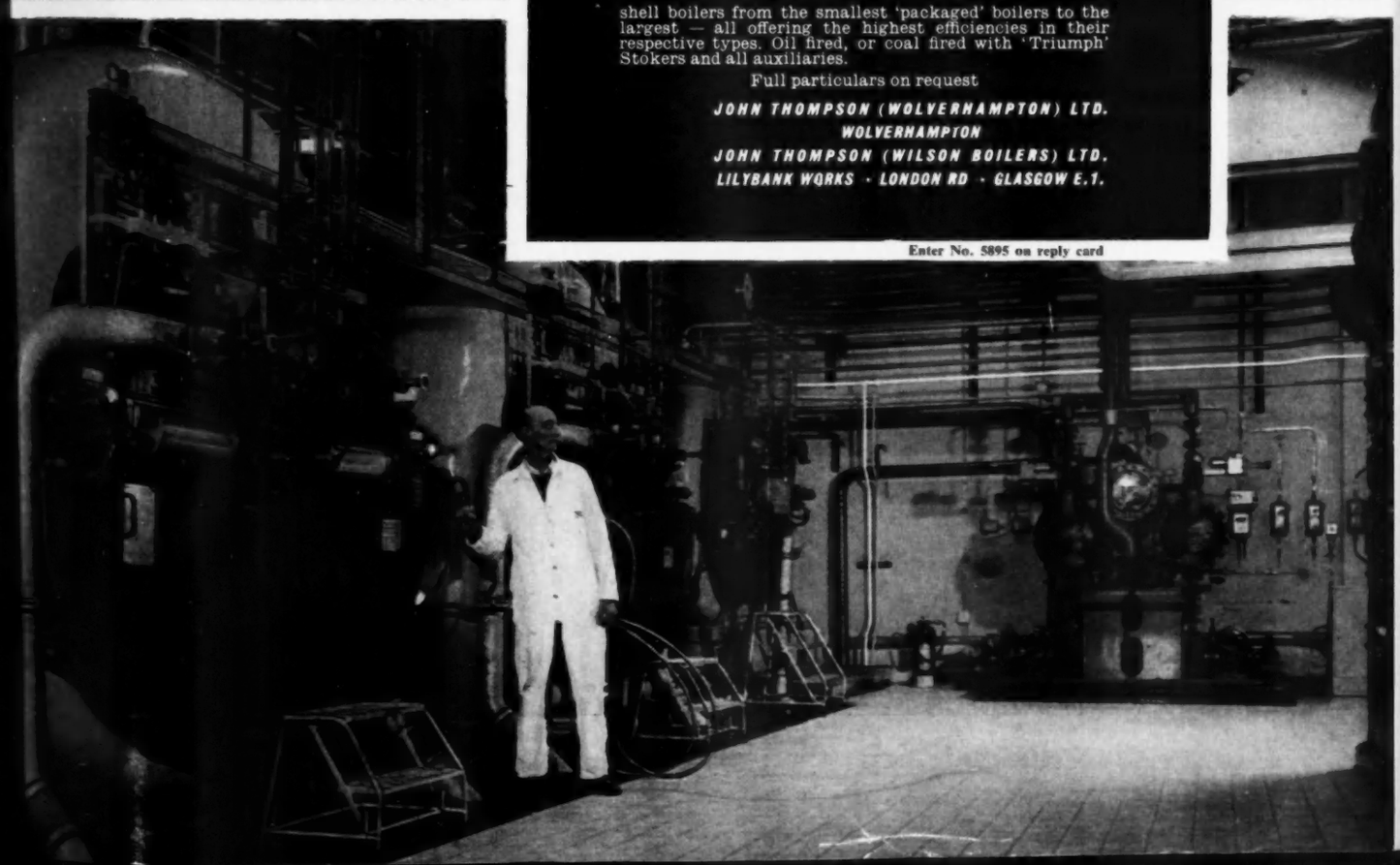

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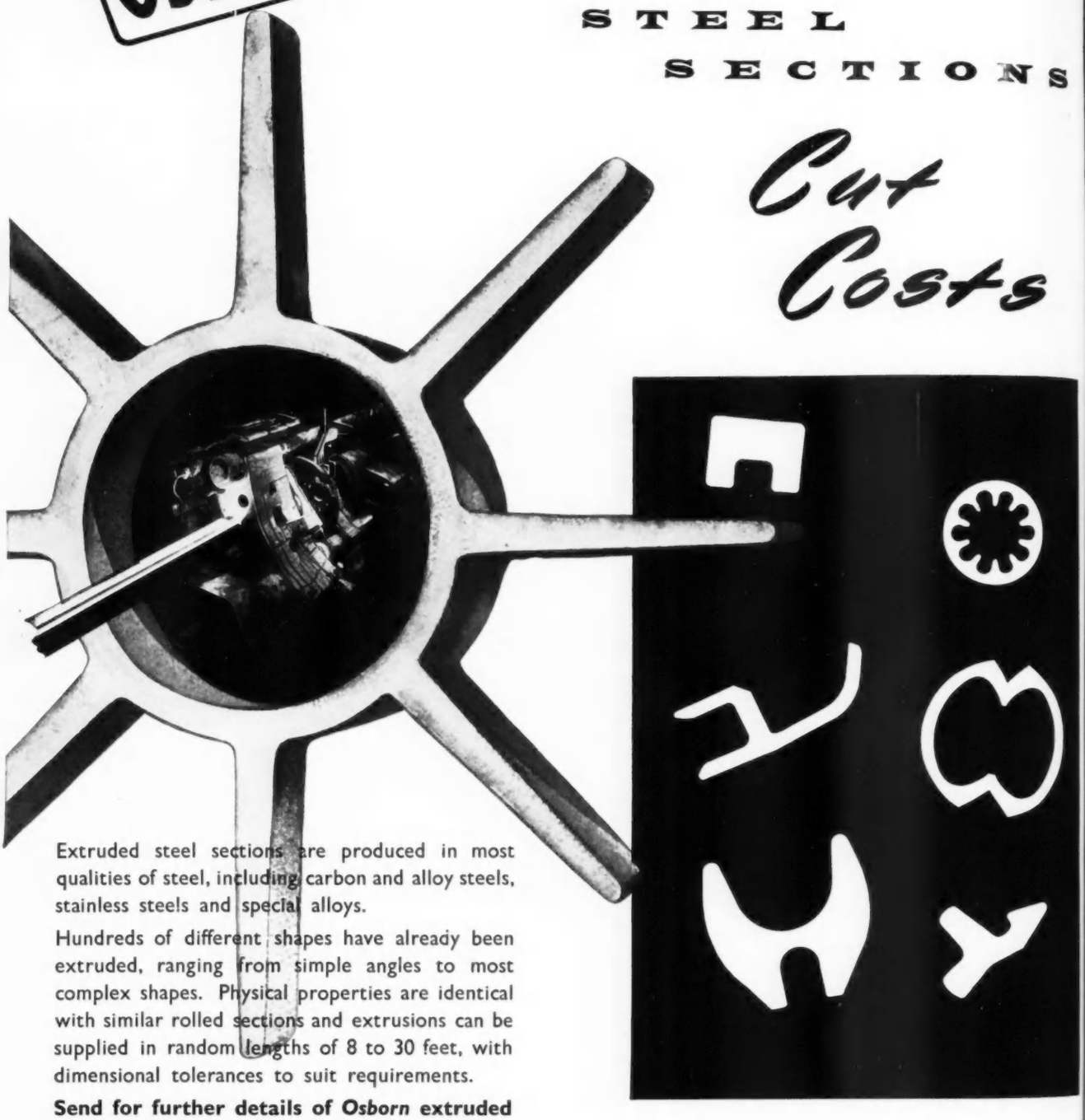

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No. 5508 AUGUST 18, 1961 Vol. 212

PROPOSALS OF LONDON DOCKS USERS

The London Chamber of Commerce has issued its final report to be submitted as evidence to the Rochdale Committee. It points out that the port user is the helpless sufferer when there are stoppages at the docks. It is also underlined by the chamber that the port exists for the user so that he has every justification in offering suggestions for improving port operation. These suggestions are treated under the headings of Labour, Organisation and Facilities, and Access. Under the first heading the opinion is expressed that most complaints would be eliminated if there were no unofficial strikes, coupled with labour co-operation in the adaptation and adoption of modern methods. Furthermore, it is contended that years of unrest, and the related damage to the country's economy, have rendered the Devlin Committee's conclusions in the Dock Labour scheme invalid so that the Rochdale Committee should make a completely new approach. Another suggestion is that the running of the docks should be by employers' representatives, since co-operation by Union representatives is disliked by the members of the unions. Use of unregistered labour in the event of an unofficial stoppage is recommended as protecting the rights of port users, while the strengthening of union discipline is considered an essential coupled with the making of unofficial strikes illegal. Contact between users and dock workers is thought to be a way of creating better all round understanding and it is urged in the report that the criterion to be borne in mind is the interests of the port users since their activities are concerned with the country's overseas trade which governs the general standard of living.

Turning to Organisation and Facilities the report suggests the formulation of a plan to meet future demands on the port and leaving the question of financial assistance to carry out the scheme to be considered by the Government on the basis of national advantage. Lack of berths for certain classes of vessels is considered to be a part cause in the diversion of trade from London, and it is felt that facilities are below requirements for the rapid turn round of ships and for the optimum use of space. Points are made in the report about the co-operation of users and others concerned in avoiding congestion in delivering and collecting goods. More efficient use of both rail and road access is recommended, including a better spread of delivery and the designation of clearways in association with one way streets so as to expedite the flow of traffic. The report stresses the national importance of creating an improved flow of exports and imports which means that the interests of the port user, as the customer, should be the yardstick measuring any course of action. Although the customer is not always right, trouble at the docks in recent years does support the contention that the present arrangements are not satisfactory and that a completely new approach to this problem is required. Certainly if the medicine previously prescribed has not effected a cure then a new diagnosis must be made and the medicine be changed.

DETERGENT FOAMS

There is a tendency amongst scientists, more, we think, than amongst engineers, to assume that the application of new scientific knowledge must necessarily benefit mankind. In fact the assumption almost invariably needs qualification. The use, for example, of certain chemicals for the pretreatment of seeds so as to protect them against plant diseases certainly increases the yield of the crops so treated. Unfortunately it has been more or less definitely shown recently to result in the deaths of several varieties of birds and of certain animals which prey upon those birds or eat the carcases. One cannot help suspecting that there may be undetermined reactions on man himself! Detergents, to come nearer home to engineers, provide another example. The housewife, even though she may be nauseated by the kind of TV advertising in which competing firms indulge, could not now do without them. A blessing has been conferred upon her. But the sewage works engineer surely will not think the same; nor will the engineers of river boards and of water supply authorities! There are examples of foam created by detergents almost overwhelming sewage works and making the navigation of rivers or any other use of them nearly impossible.

Fortunately in this matter of detergents progress is really being made. There is a Standing Committee on Synthetic Detergents which was appointed by the Minister of Housing and Local Government in January, 1957. Naturally it has benefited from the co-operation of river boards, water undertakings and local authorities responsible for the operation of sewage works; and it has sought and obtained assistance from committees active on the same subject in America and Germany. Less expectedly to those who take a more jaundiced view of industry than we do, it has also benefited from the co-operation of a number of firms manufacturing synthetic detergents. There has been developed a new detergent material, similar to that in general use, but more readily decomposed biologically. In the fourth report, just issued by the Committee, reference is made to initial tests, carried out with this material at Luton and Harpenden, more fully reported upon in the third report. Those tests were made possible through the co-operation of the manufacturing firms which agreed to supply within the areas draining to the Luton and Harpenden sewage works only the new "soft" detergent. The tests showed an encouraging reduction in the amount of foaming in the effluents and in the river below the effluent outfalls. Since then further tests have established that whereas a full-scale sewage works can remove 68 per cent of "hard" detergent it can remove 80 per cent of "soft." That latter figure compares with 94 per cent in a special experimental plant and the difference is not easy to

explain. The committee concludes that were there complete substitution of "soft" for "hard" detergent nationally the concentration of synthetic detergent in effluents from sewage works could be reduced by about a half. However, there appear to be difficulties in replacing more than about 80 per cent of the "hard" by the "soft" detergent. Moreover the committee is becoming more concerned than it was originally about the effects upon rivers and upon the work of water supply authorities of the quantity "of measured residual detergent plus the unmeasured degradation products" after sewage treatment. The conclusion to be drawn from the report appears to be that the substitution of the "soft" for the "hard" detergent could certainly prove useful, more particularly where foaming is at present only light or moderate; but that before a recommendation for the national substitution of "soft" for "hard" material can be made further investigations need to show that the substitution will really result in a reduction in the total residual materials in sewage effluents. The real problem "is so to control the composition of the mixture that those substances which resist rapid and complete biological breakdown can be eliminated or at least reduced to unimportant proportions." In the view of the committee "If the attempts which have been and still are being made to solve the difficulty on these lines prove fruitless then the solution may have to be sought in the development of a surface active agent of a completely different kind from the alkyl benzene sulphonate now in general use." Many, however, who have to put up with the inconvenience, not to speak of the occasional danger, of foaming will feel sorry that despite the further delay the committee feels unable to recommend the national adoption wherever possible of "soft" detergent now. For given such a lead we think the manufacturers, who proved so co-operative in making a success of the experiments at Luton and Harpenden, would have proved willing to make "soft" detergents available nationally within a very short time.

SAFETY

We make no apology for once again drawing attention to the greater need for safety in industry — for in the first quarter of this year no less than 179 people lost their lives and 48,461 were injured in notifiable accidents. We have frequently in the past drawn attention to the distressingly high number of accidents which persist in industry — a majority of which result from the failure to observe elementary precautions or use of equipment provided for the protection of employees. Agreed that more attention is now given to safety than at any time in our industrial history, but the accidents described in the quarterly publications of H.M. Inspector of Factories show that much is still lacking either on the part of employers or in the training and discipline of employees. Perusal of the latest of these publications again shows that although some of the accidents occurred as a result of mechanical failure most could have been anticipated and avoided by elementary precautions or just plain common sense.

It is stated in the publication that manual handling of goods and materials causes some 40,000 accidents a year — over a quarter of the reportable accidents occurring in the country. In this day and age with so many mechanical handling devices and aids to manual lifting and handling it is not easy to understand, much less be complacent about, that number of accidents. Wherever work is involved there will always be an accident hazard, but there is no doubt that a greater measure of forethought on the part of workers and keener supervision by executives can do much more to avoid the unnecessary loss of time and labour and the suffering entailed in accidents. It is an indisputable fact that accidents do not just happen, in some measure they are always the result of human failing, carelessness or failure to observe due precautions at some stage.

It is interesting to note in a recent issue of *Pennant*, the house journal of the British Oxygen Group, that at the Chester-le-Street Chemicals Plant the wearing of safety helmets is a condition of service, failure to do which is penalised by dismissal. This concern, like many other large firms, has an active safety officer, but there are even now too many establishments where disciplined safety is lacking. A firm not taking satisfactory safety precautions can be taken to law and penalised — an employee who disregards precautions available in his own and other workers' interests should likewise be penalised by instant dismissal. Often there are small firms where both employers and employees say that a certain amount of risk must be faced if production is not to suffer. We wonder how often this really is the case and venture to suggest that it is generally the result of "parochial practice" where, if internal knowledge cannot see a means of eliminating or avoiding a risk, outside experience might well be sought to advantage. Human suffering can and should be avoided and risk to life and limb can never be justified in the interests of industrial production with the facilities and experience now available.

CONDITIONS IN FOUNDRIES

Foundries are not noted as places affording particularly healthy and pleasant working conditions, though not all the strictures directed at them are justified! Nevertheless, there is scope for improvement in many a foundry, large and small. There are two aspects of the problem of improving conditions in foundries, the technical and the psychological; of the two the latter is probably the more intractable. A lot of work has been done on the problem, and some of the answers have been found. Details of the work done in one section of the foundry industry are given in a recent report "Conditions in Steel Foundries" (H.M. Stationery Office, 10s.). It is true that the report is concerned, as its title indicates, only with steel foundries, but many of its findings apply equally to other types of foundry, and even to some completely different industrial concerns. One of the major problems in foundries is the elimination, or at least the control, of dust and fumes. Both are at all times a nuisance. Both can be, and often are, dangerous to health. A great deal of work has therefore been directed to solving this particular problem, and some successful methods have been evolved for the control of the hazard.

Information on the subject is readily available and it is disappointing to find from the present report and from others, to say nothing of personal observation, that the solutions to the dust and fume problems are not always applied as they could, and should, be. The same applies with the other hazards found in, though not peculiar to, foundries. Indeed, the present report says that the industry needs ". . . . a higher standard of housekeeping." So many of the things which could be done to improve conditions are simple and inexpensive that it is difficult to see why they are neglected. Again, it is all too often the case that a simple and effective precaution is put into practice and then forgotten. A clearly-marked gangway is of little use if somebody

leaves a casting projecting across the darkest part of it. An effective dust extraction system soon becomes a costly absurdity if the filters are choked, dirty, or broken. This is all very elementary, yet it does happen, all too often.

That is why psychology comes in. Sufficient technical knowledge exists to make an immediate improvement in foundry conditions possible. What is needed now is the will, on the part of both management and men, to have improved conditions, to keep them, and to seek means of making them better still. That is easy to say, but difficult to achieve. Neither persuasion nor compulsion is the complete answer, and the latter would surely be undesirable even if it were practicable. Some compulsion is necessary of course. Deliberate misuse of equipment designed for everybody's good merits inquiry and if it is found to arise from malice or even from prejudice may require to be met by strong measures. Carelessness (remembering, however, that no human being can ever be sure that he will not sometime or other be careless) cannot be overlooked either. But the best answer is the will of all concerned. Publicity can help a lot, but it must not be overdone. Nobody likes being pushed and that is what he will feel is happening to him if he is subjected to too heavy a barrage. One thing that can be done (and it is not always) is for managerial staff to set an example, by adopting all the approved safety methods while in the works. If it is important for a workman to wear a safety helmet or goggles in a particular situation, it is equally important that some one shall be able to insist that the works manager and the managing director and any visitor to the works shall do so too when they go to the spot in question. Where there is equality of hazard, there must be seen to be equality of precaution. We know of a number of firms which insist on this procedure. We wish there were more of them.

BOOKS FOR REVIEW

For some time we have been dissatisfied with the treatment we have been able to give to books sent in to us for review by publishers. Earlier in this century there was no difficulty at all. The number of books published on engineering subjects was not large and we were able to provide adequate reviews of almost all of them. Even between the wars, when the number of technical books published began noticeably to increase, we were able to cope because many of them were textbooks for undergraduates and similar works not requiring extensive review. But since the second world war the flow of technical books from the publishers has become a flood. Moreover THE ENGINEER covers a wide and still widening field. Indeed we sometimes, under stress, look back nostalgically a hundred years or so to a time when there were no motor-cars, no aircraft and almost no internal combustion engines, when electrical engineering was in its infancy and electronics unheard of; when nuclear power was undreamt of; when there was little if any true engineering research, but only development; and when the only really important mechanism for a mechanical engineer to understand was the piston in cylinder and crankshaft arrangement. Compared with the quite recent past we now find ourselves receiving in a month as many books for review as we used to receive in a whole year, yet we have not been able to give up much more space than in the past to reviews of books. The consequence, of course, has been that a smaller proportion of books submitted to us has actually been reviewed in our pages. Merely the receipt of the remainder has been recorded in our columns under the heading "Books Received."

Now there is to be a change. In this issue a new feature will be noticed. Under a heading "Books just published" very short descriptions appear of the contents of books; and other particulars, such as the price, number of pages, whether illustrated, &c. are also given. Henceforth this treatment will be accorded every first edition offered to us for review, provided the book concerned covers a subject within the field of THE ENGINEER. Those descriptions will be published within a month of the date of publication. We believe that, restricted though it is, this information about the books will be helpful to librarians and to prospective buyers. We emphasise again that all first editions will receive this treatment. Regretfully we have to add that second and subsequent editions of books will not, unless there are really substantial additions or changes. The receipt of such editions will continue to be recorded in our "Books Received" column. This change does not mean that we intend to cease reviewing adequately a proportion of the books sent to us for review. We hope in fact to do so more adequately. All first editions without exception will receive notice under the new heading "Books just published." Some will, in addition, be selected for more lengthy and more critical review at a later date. These reviews will be published once a month in a new "Review of Books." We have plans for the making of certain changes in our methods of reviewing these books in the new section. But comment on those plans will be better delayed until they have been implemented.

The Engineer—100 Years Ago (AUGUST 16, 1861)

"THE STEAM TRIALS AT LEEDS"

"In class 1 the most prominent and novel machine was certainly Romaine's steam-digger, exhibited by Brown and May. There can be no doubt that a great deal of ingenuity and inventive talent is displayed in the construction of this steam-cultivator. But it is equally certain that in its present state it can never produce any satisfactory result. It has now been many years before the public, and although under the most favourable circumstances it did make an excellent seed-bed at Leeds, the wear and tear of the implement and the consumption of fuel, water, and oil, were tremendous. It is quite possible to buy gold too dearly; and if all the damage sustained by the engine and digger in making that small extent of perfect seed-bed was calculated, the sum would amount not only to the value of the crop, but pretty nearly to the fee simple of the land. It was, therefore, quite out of the question for the judges to award even a medal to so impracticable and unprofitable a system of cultivation, however much they might have been charmed with the talent and ingenuity of the inventor. We are quite certain that on soft land the passing of such a ponderous weight over the soil would not only be a great drawback to good cultivation, but also seriously impede the progress of the machine. Even on the hardened soil at Garforth the engine laboured fearfully to obtain only a moderate speed.

"Mr. Richardson's pretty little engine, with its light steel boiler, is much better adapted to move over the ground; yet the passage of such an engine across any but the lightest of soils must be detrimental to perfect tillage. It is one of the chief advantages of steam-cultivation that it does away with the kneading and treading of horses' feet, but that evil is augmented rather than diminished if even the lightest engine is to stalk over the land."

High Pressure Research at the National Engineering Laboratory

H. Ll. D. PUGH, B.Sc., F.Inst.P., F.I.M.,* J. LEES, M.A., Ph.D.,*
K. ASHCROFT, A.M.I.Mech.E.* and D. A. GUNN*

1. Introduction

IN every branch of science and technology today, research is being directed to extending the boundaries of knowledge by the introduction of new techniques. The development of techniques for obtaining high pressures has added a new dimension for the extension of knowledge. High pressure research which was pioneered by Bridgman is of particular interest and has recently stimulated considerable research effort in a number of different fields, particularly in chemistry, geology, engineering, physics and metallurgy.

Of particular interest to the engineer is the effect of high pressures on the properties and behaviour of materials. Work on this aspect is in progress in the Plasticity Division, National Engineering Laboratory, and a brief outline is given in this article. The work falls into three categories, namely, the effect of high pressure on the mechanical properties of materials, the use of high pressures in the forming of materials, and the combination of ultra-high pressures and high temperatures in the synthesis of new materials.

2. The Effect of High Pressure on the Properties of Materials

It is frequently stated that the yield and flow stresses of metals are a function of the shear stresses and are therefore not affected by hydrostatic stress. Whilst there is a certain amount of supporting evidence based on various types of combined stress work, there is also some contrary evidence due to Ratner[1] suggesting an appreciable effect of hydrostatic pressure on the stress-strain curve. This question can be resolved by the determination of the stress-strain curve for a given metal under various ambient pressures. In addition, this work can throw considerable light on the criterion of ductile fracture and on the increase in strain to fracture, both of which are significantly affected by the ambient hydrostatic pressure.

2.1. *High Pressure Techniques.*—The method normally used at N.E.L. for obtaining the requisite high hydrostatic pressures up to 100 tons per square inch (15,000 atmospheres) is shown in Fig. 1. The high pressure container *A* is a tapered fit into the support collar *B* and is separated from it by a thin lead sheet *C*. With this arrangement the radial support provided by collar *B* increases automatically with the fluid pressure in the bore of chamber *A*. The increasing fluid pressure acting on the annular shoulder in the bore forces the container *A* further into the collar *B* (with the lead acting as a lubricant) and thereby induces a greater support from the collar *B*. The high pressures are generated by forcing inwards, under the action of a press, the plungers *D* which close each end of the bore. The sealing arrangement *E* used on the moving plungers consists of a standard rubber O-ring on an anti-extrusion ring, usually of beryllium copper. The method adopted for taking insulated electrical leads into the high pressure chamber is shown in Fig. 1. A ceramic conical shell component *F* fits into a tapered hole in the plunger head and a tapered steel terminal *G* fits into *F*. Careful lapping of these members into each other ensures satisfactory sealing at the high fluid pressures, and the ceramic insulates the electrical leads from the chamber. As many as nine connections are commonly made through a 1½in diameter plunger.

Normal hydraulic oils freeze at room temperatures at the order of pressures employed here. Consequently, high pressure fluids such as iso-pentane, mixtures of castor oil and methyl alcohol, etc., are commonly used. The fluid pressure is measured by the change in electrical resistance of a small coil, about ¼in diameter, of 45 S.W.G. manganin wire. Manganin is used because of its relatively high pressure coefficient of resistivity, being about $3{\cdot}7 \times 10^{-4}$ ohms per ohm per ton per square inch, and its low

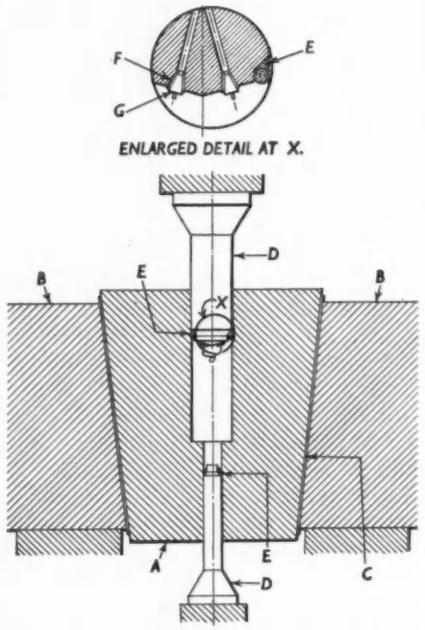

Fig. 1—Equipment used to produce high hydrostatic pressures

temperature coefficient. A calibration of this gauge in a dead-weight tester to 40 tons per square inch is quite linear. This was also found to be true, by Bridgman, up to pressures of nearly 85 tons per square inch.

2.2 *Mechanical Tests Under Pressure.*—The problem of carrying out even simple mechanical tests such as tension and torsion in a high pressure chamber presents major experimental difficulties. The techniques evolved are described below.

The apparatus for tension tests under pressure is shown in Fig. 2. The top plunger is forced into the container by a hydraulic press to develop the required hydrostatic pressure around the tension apparatus. The bottom plunger is lowered and this allows the mechanism to be lowered down onto the shoulder of the container and by means of a seal (not shown) at this point, isolates the top bore from the bottom bore. Further downward movement of the bottom plunger causes the tension plunger to move downwards under the pressure differential. The specimen is thus pulled in tension under the hydrostatic pressure prevailing in the upper chamber.

The load gauge consists of a steel tube on which are mounted foil gauges. It is necessary to determine the calibration of this gauge under fluid pressure. This is done by measuring, with the pressure gauges, the pressure differential across the tension plunger using a dummy specimen. At a pressure of 30 tons per square inch agreement within 2 per cent with the atmospheric calibration has been obtained. The strains are determined from a continuous photographic record of the necked area of the specimen; this is obtained by projecting a beam of light through the cross-bored hole in the container, sealed off with glass windows (see Fig. 2), and focusing the image of the specimen on the ground glass screen alongside the load indicating meter. A typical photograph of a necked specimen is shown in Fig. 3. This method is perfectly satisfactory for observing in silhouette any phenomena in a high pressure chamber.

The apparatus for carrying out torsion tests under pressure is about 1⅛ in diameter and 7½in long, and consists of a small electric motor and reduction gear box, a torque tube (bonded with foil gauges) and the specimen in series. The angle of twist is measured by a small brush making contact with the teeth of one of the gears. The unit operates in the pressurised liquid and power losses are minimised by the use of low-viscosity fluids, such as iso-pentane. Torques of 30 lb-inches have been achieved in iso-pentane at a pressure of 50 tons per square inch.

2.3. *Results.*—The results of this work are generally in agreement with Bridgman's finding and show that metals show an increase, sometimes most marked, in ductility or strain to fracture when tested under pressure, as seen in Fig. 4 for zinc and aluminium. However, unlike Bridgman's conclusions, a linear relation between the strain to fracture and pressure has not been obtained. In some cases, e.g., aluminium and copper, the deviation from linearity is small, whilst in others, e.g., zinc, it is most marked.

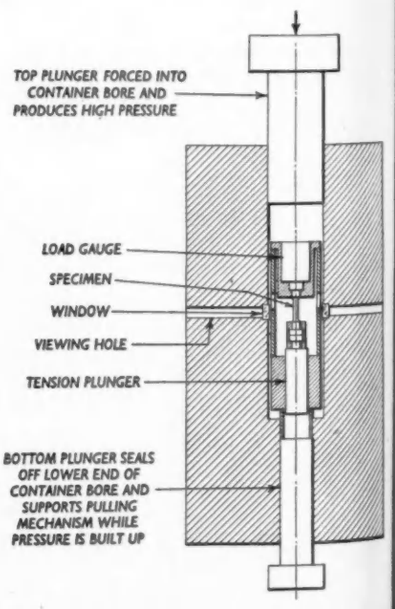
TOP PLUNGER FORCED INTO CONTAINER BORE AND PRODUCES HIGH PRESSURE
LOAD GAUGE
SPECIMEN
WINDOW
VIEWING HOLE
TENSION PLUNGER
BOTTOM PLUNGER SEALS OFF LOWER END OF CONTAINER BORE AND SUPPORTS PULLING MECHANISM WHILE PRESSURE IS BUILT UP

Fig. 2—Apparatus for tensile tests under pressure

* Plasticity Division, National Engineering Laboratory.

Fig. 3—Tensile test under pressure showing necked specimen and applied load

Indeed, in the case of zinc, the transition from a fully brittle to a fully ductile state occurs quite suddenly over a very narrow range of hydrostatic pressure, as seen in Fig. 5, and seems to be analogous to the sharp transitions which occur in some metals as the temperature is changed.

A comparison of the results for cast iron of torsion tests under pressure due to Crossland and Dearden[2] and the tension tests under pressure at N.E.L. has shown that good agreement between the two sets of results is obtained on the basis of a maximum principal stress criterion of fracture, but not on a shear stress criterion.

With the development of equipment and techniques, N.E.L. possesses excellent facilities and experience for high pressure research. These facilities have been used for pressurising thick walled tubes, bursting tests on dics and tubes, 'soaking' of metals under pressure, etc. Another interesting application is the compacting of metallic powders under hydrostatic pressures, which enables uniform compactions to be obtained. This is carried out by filling a rubber bag moulded to the desired shape with the powder and sealing. After subjecting to the required pressure, the bag can be stripped off without damage to the compacted powder. Densities of 90 per cent of the theoretical density have been obtained in this way before sintering.

3. The Application of High Pressures to the Forming of Materials

It was observed in the above work that hydrostatic pressure has a marked effect on the ductility of materials, presumably by the inhibition of cracking. This fact probably explains the success of forming processes in shaping metals without cracking. In such processes the design of dies, rolls, &c., are such as to build up stress systems in the deforming region which have large compressive components of hydrostatic stress, i.e., the average of the three principal stresses is large and compressive. When the material deforms under these conditions it exhibits the same enhanced ductility as when tested under a high fluid pressure. It is therefore not surprising that strains many times larger than the fracture strain in ordinary mechanical tests can be obtained in formation processes.

If this hypothesis is correct then a marked improvement should be obtained in cases of materials which cannot be formed satisfactorily, i.e., without cracking, by increasing the hydrostatic stress component in the deforming region. This can be done if the process is carried out in a pressurised fluid. Experiments on the extrusion of metals have been carried out along these lines.

3.1. *Extrusion of Brittle Materials.*—The method of carrying out extrusion under a superimposed fluid pressure is illustrated in Fig. 6. The high-pressure chamber is closed by an upper and a lower plunger *A*. Butting on to the top plunger is the extrusion ram *B* which fits into the extrusion chamber *C* which in turn is screwed on to the die *D*. The chamber and die assembly is located by rings *E* and sits on a conical seat in the chamber. The arrangement shown is that for the extrusion of tube from a hollow slug *F*, which has a pilot or mandrel passing through its central hole. A manganin wire pressure gauge *G* is used for measuring the fluid pressure and the leads are passed to the outside of the chamber through the insulators *H*.

After the extrusion assembly is placed in position, the high pressure chamber is filled with a suitable fluid, usually paraffin. The top plunger is then forced in under the action of a hydraulic press, thus pressurising the fluid. The fluid pressure at which extrusion begins can be regulated by controlling the volume of paraffin introduced initially or by altering the position of the lower plunger A. Generally speaking in these

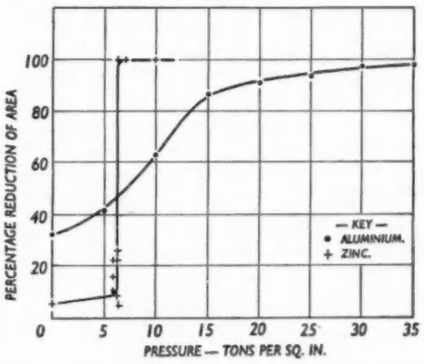

Fig. 4—Effect of hydrostatic pressure on the percentage reduction in area for zinc and aluminium

tests plunger *A* has been kept fixed and the hydrostatic pressure in the chamber has risen during the extrusion process.

Two materials which have a limited capacity for cold work under normal conditions and, in particular, cannot be cold extruded at atmospheric pressure without cracking, are magnesium and bismuth. However, when their extrusion is carried out in a pressurised liquid as described above, marked improvements are obtained and it is relatively easy to obtain an uncracked product.

The improvement achieved by the extrusion of magnesium at a ratio of 2·97 under a hydrostatic pressure which increased during the extrusion is illustrated in Fig. 7.

Experimental results have indicated that a superimposed hydrostatic pressure of 2 to 3 tons per square inch may be adequate to suppress the brittle behaviour of these two metals at low reductions. This suggests the existence of a critical pressure which under given conditions can inhibit cracking. Further, it is to be expected, (and there is also experimental evidence for this), that the greatest requirement for hydrostatic pressure is at low reductions. This is illustrated in Fig. 8 which shows the

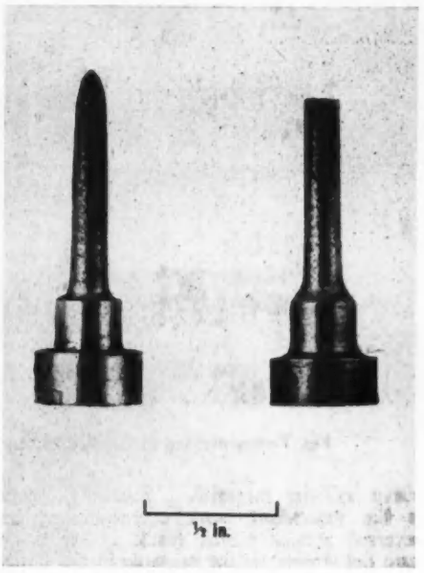

Fig. 5—Zinc pulled under pressures of 6·5 and 6·3 tons per square inch respectively

critical hydrostatic pressure required to inhibit cracking of the bismuth product as a function of extrusion ratio.

At high extrusion ratios the critical superimposed hydrostatic pressure decreased, as indeed it did for extrusion ratios of less than 2.

The application of this method to the cold plastic deformation of high strength brittle materials is now receiving attention. If the method is successful then it has two potential uses. In the first place it will be possible to produce extruded shapes in such materials. In the second place, the ability to produce cold plastic deformation of brittle metals by this method could lead, after a subsequent heat treatment, to a refined grain size, thereby endowing the metal with some ductility.

3.2. *Hydrostatic (or Ramless) Extrusion.*—In conventional extrusion, the pressure required or work done to carry out the process is determined by three factors. In the first place there is the work required to carry out a homogeneous deformation, i.e., corresponding to an uniform extension (without necking) until the diameter is reduced to that of the extruded product: this can be obtained from the stress-strain

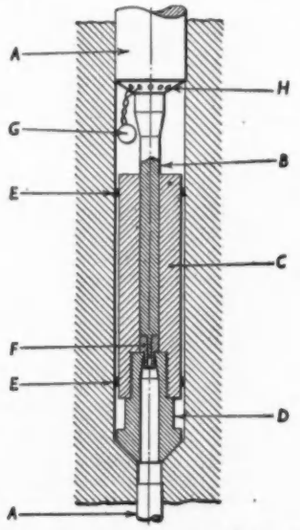

Fig. 6—Rig for extrusions under high hydrostatic pressure

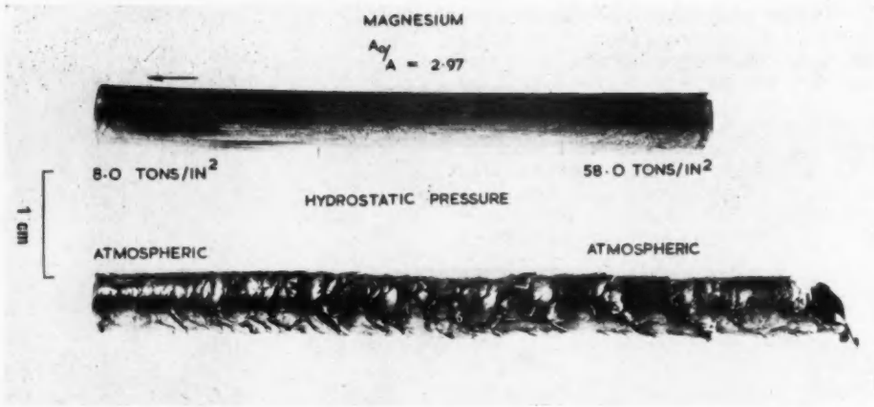

Fig. 7—Improvement in the cold extrusion of magnesium using hydrostatic pressure

curve of the material. Secondly, there is the redundant work corresponding to reversed strains which result in small or zero net strains, as for example in the fibres near the outside of the billet which are initially bent to move towards the die and are then straightened on passing through it. This redundant work is determined by the geometry of the flow pattern, and is clearly smaller for conical dies than for square-entry dies. Finally, there is the work done against friction at the die-billet interface and at the container wall-billet interface. It may therefore be appreciated that conventional extrusion is a relatively inefficient process.

The technique of hydrostatic or ramless extrusion is attractive in that it attempts to reduce all the factors which introduce unnecessary work in conventional extrusion. It was first attempted but not developed by Bridgman.[3] Currently the application of fluid pressures to the cold forming of metals is being actively pursued in the U.S.S.R. by Vereshchagin and his colleagues at the Physics of High Pressure Laboratory, Moscow.

The apparatus used at N.E.L. for this hydrostatic extrusion is shown diagrammatically in Fig. 9. This shows the use of a fluid pad interposed between the ram and billet and between the billet and container wall. The billet is previously nosed to fit a conical die and forms an effective seal which allows fluid pressure to be generated above and around the billet. The presence of this high pressure lubricant between billet and container and adjacent to the die is of major importance. Clearly the friction between billet and container is completely eliminated. Furthermore, during extrusion high pressure liquid is partly forced and partly dragged along the conical die face, thereby maintaining lubrication, and so reducing friction on the long conical dies and enabling long products to be extruded. Again the ability to use small angled dies reduces the redundant work.

Experiments have been carried out using 1in diameter billets of commercially pure aluminium, and an aluminium alloy to HD30 specification, containing manganese, silicon, and magnesium. These have been extruded through conical dies ranging from 150 deg. to 20 deg. included angle at reductions in area of up to 96 per cent (i.e., an extrusion ratio of 25 : 1). It was clear from the deformation of grids originally scribed on an axial plane that frictional effects are small and, particularly for small angled dies, the variation of strain, and therefore the variation of properties across the product, is minimised.

The effect of reduction on fluid extrusion pressures is shown in Fig. 10 for dies of 90 deg. and 45 deg. included angle. These results may be compared with the pressures required for conventional extrusion through square dies (180 deg.) both at room temperature and at 400 deg. Cent. Considerable reductions in extrusion pressures are therefore achieved, particularly for conical dies of 45 deg. and below. Furthermore the fluid pressures required were not as high as might have been expected when compared with those for hot extrusion for the materials used in this investigation, being less than 100 per cent higher even for a 90 deg. die. Whilst the relative merits of this hydrostatic extrusion and hot extrusion would need to be examined in more detail, there may be many cases where the increase in extrusion pressure is well worth the advantages of cold working.

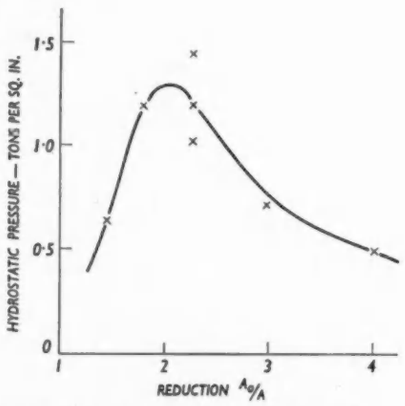

Fig. 8—Hydrostatic pressure to inhibit cracking of bismuth extrusion at different extrusion ratios

Current research at N.E.L. on the use of high pressure in the extrusion of metals is aimed at combining the two methods outlined above, particularly in cases of high strength brittle materials such as beryllium and its alloys. In such cases the back pressure acting on the product will enable a sound uncracked product to be formed, whilst the use of a fluid pad to carry out the extrusion will reduce to a minimum the extrusion pressures required.

It is expected that the application of high pressure fluids to other selected formation processes will also meet with comparable success, and future work is being directed to this end.

4. Ultra-High Pressures and Temperatures

Research into the structure of matter has made great advances in recent years. One of the most interesting developments has been the discovery of the potentiality of ultra-high pressures and temperatures in producing new materials. The ultra-high pressure research programme at N.E.L. is concerned with a study of phase changes which are likely to produce new hard and refractory materials for the engineering industry. Pressures up to the order of 100,000 atmospheres and temperatures of up to 3000 deg. Cent are required for this work.

In general, high pressure favours processes which give a decrease in volume and thus there is a tendency for the lattices of substances to be forced into new more closely packed arrangements. However, the reaction rates are often extremely small and so it is necessary to increase the temperature to obtain transitions in reasonable times. These reaction rates are critically important in some phase changes and only by suitable control can certain transitions be achieved, e.g., in the case of the graphite-diamond transition.

Above about 30,000 atmospheres (200 tons per square inch) we may consider pressures to be "ultra high." This is about the limiting pressure which can be produced in the relatively simple piston and cylinder type of apparatus so far discussed. Further, this pressure is also about the freezing pressure at room temperature of even the best high-pressure liquids. It will thus be appreciated that the use of solids as pressure-transmitting media is necessary. This fact and the combination of extreme pressures and temperatures demand the use of new and ingenious designs for ultra-high pressure work.

4.1. *Design Considerations.*—It is obvious that in order to contain such extreme pressure it is necessary to construct the most highly stressed part of the apparatus from the strongest available material. A commonly used material is cemented tungsten carbide, the grade with 6 per cent cobalt binder having a compressive strength as high as 350 tons per square inch. Since, however, the material is relatively weak in tension, the design of the apparatus must be such as to aviod excessive tensile stresses in the carbide by providing adequate mechanical support.

It is clear that even a tungsten carbide plunger could not sustain 100,000 atmospheres (630 tons per square inch) over its end. To meet this difficulty, Bridgman

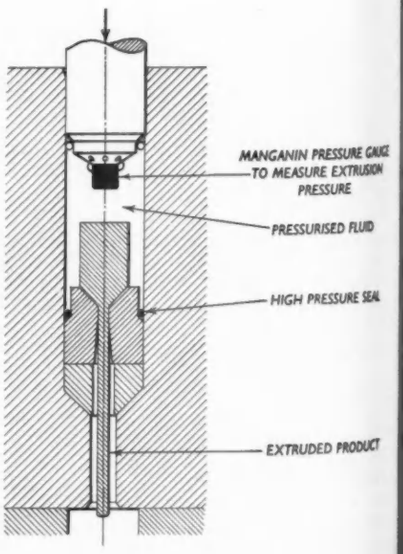

Fig. 9—Apparatus for cold extrusion by fluid pressure

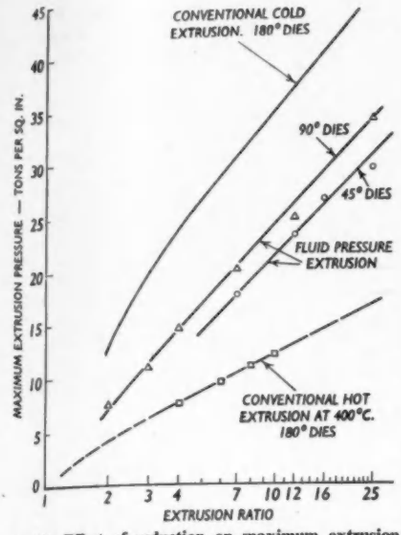

Fig. 10—Effect of reduction on maximum extrusion pressure for aluminium (99·5 per cent purity)

originated the massive support principle. In his simplest apparatus, two anvils were used, each being slightly tapered from a small flat circular loading area. They consisted of a tungsten carbide insert, shrunk or force fitted into a massive steel ring, similar to that shown in Fig. 11*a*. These anvils were forced against the flat faces of a disc-shaped solid pressure transmitting medium. Thus, high pressures could be generated over a small area of the tungsten carbide insert which receives good mechanical support from the supporting steel. It is expected that pressures approximately three times the compressive strength of the anvil can be applied to the small area in this way.

A suitable material as a solid pressure transmitting medium is pyrophyllite, a naturally occurring hydrous aluminium silicate. It is an easily deformable material and is capable of giving approximately hydrostatic conditions. Further, it has the advantage that when subjected to high pressure, the amount by which it extrudes into the narrow gaps between the anvils is limited and it forms an excellent gasket material. It is also a good thermal and electrical insulator and so is ideal for allowing high temperatures to be developed in a specimen under pressure, and yet keep the anvil temperatures to a minimum.

These principles have led to the development of two distinct classes of ultra-high pressure apparatus. Firstly, there are various modifications of the piston and cylinder apparatus, usually with special support for the pistons, which are the weakest point of this design. Examples of this have been given by Boyd and England[4] and by Hall[5] with his elegant "Belt" apparatus devised for diamond synthesis by General Electric.[6]

In the second class is the tetrahedral apparatus devised by Hall[7] in which the pressure-transmitting medium is in the shape of a tetrahedron. Against each triangular face is forced an anvil backed by a hydraulic cylinder.

4.2. *The N.E.L. Tetrahedral-Anvil Apparatus.*—In Hall's original design, each anvil was powered by a separate hydraulic ram. This is rather cumbersome particularly in a large apparatus. N.E.L. is therefore using a modification suggested by Lloyd, Hutton and Johnson[8] in which the external force is applied only to the top anvil by means of a conventional press. The back faces of each of the other three anvils butt accurately on the inside conical face of a steel ring and wedging reactions provide the necessary thrusts as shown in Fig. 11(*b*). "Teflon" sheets 0·015in thick are placed behind the back face of each anvil as shown, to decrease friction. They also insulate the anvils electrically from the cone. One of the flexible copper heating current leads is also shown in the figure, as well as two thermocouple leads to determine anvil temperatures during test.

The four anvils fit together to surround the pyrophyllite tetrahedron, leaving only small gaps between each of the six bevelled interfaces. Since the pyrophyllite tetrahedron is initially made slightly oversize ($\frac{7}{16}$in edge as compared with a face edge of $\frac{1}{4}$in), the excess material on compression extrudes into the gaps where it forms an efficient yet compressible seal. Excessive extrusion of this "gasket" is prevented by painting the anvil surfaces before use with ordinary jewellers rouge to enhance friction. The specimen is contained within a metal or graphite tube running between the mid points of opposite edges of the tetrahedron (see Fig. 12). It is heated by passing a large electrical current through this tube via two of the anvils and the metal contact tabs shown. In some cases it is possible to heat the specimen by passing the current directly through it, the specimen tube then being omitted.

In this apparatus, which was constructed in the N.E.L. workshops, the anvils have a 6 per cent cobalt tungsten carbide insert force-fitted with a nominal 0·001in to 0·002 in per inch interference into EN26 binding rings. The steel ring housing the three lower anvils is also made of EN26, and the press used was a 500-ton Fielding and Platt four-column hydraulic press. Axiality of loading during test is ensured by mounting the apparatus in a generously proportioned die set with a spherical loading cap. A low voltage source of current was used for heating, using typically 3V at 200A to produce temperatures of approximately 2000 deg. Kelvin.

The apparatus was first calibrated in order to relate hydrostatic pressure on the specimen to the load exerted by the press on the top anvil, this being measured by a 500-ton resistance strain gauge load cell. This is done by observing reversible phase transitions in certain metals. A sample of the metal being investigated is surrounded by a silver chloride sleeve and placed in the tetrahedron ; the silver chloride provides more truly hydrostatic conditions than are obtained using only pyrophyllite. The transition point is found by observing the associated electrical resistance change. Bridgman's data for the pressures at which such transitions in bismuth, thallium and barium occur have recently been revised by the work of Kennedy and La Mori,[9] showing the pressures for the latter two transitions to be about 15 and 25 per cent too high respectively.

Temperature under load may be estimated roughly from the power supplied to the heater circuit. A calibration may be in terms of the melting points of various metals, e.g., nickel, for which data at high pressures are available.[10] The melting of a metal under pressure is detected experimentally by the associated electrical resistance change.

4.3. *The Synthesis of Diamond.*—Using this tetrahedral anvil apparatus, diamond crystals have been synthesised. They were produced using a sandwich of alternate graphite and nickel with tantalum end tabs at a pressure of 75,000 atmospheres and a temperature of 2000 deg. Kelvin. A cluster of large black synthetic diamonds were obtained with well developed crystal faces.

Fig. 11(*a*)—One anvil showing cemented carbide insert fitted into steel binding ring, and also copper electrical current ring

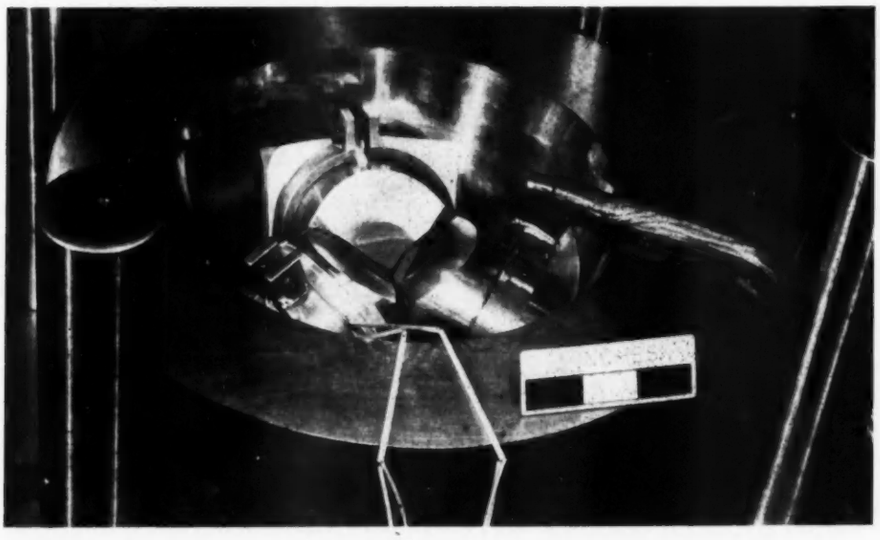

Fig. 11(*b*)—Three lower anvils mounted inside steel ring, showing current lead and thermocouple wires

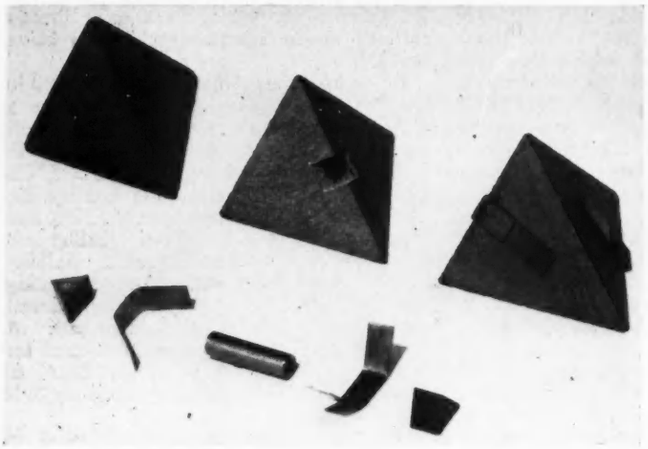

Fig. 12—Details of tetrahedron and specimen tube with contact tabs

The largest 0·3 × 0·3 × 0·4mm, see Fig. 13, sank slowly in cadmium borotungstate at room temperature showing its density to be somewhat greater than 3·3 g.cm^{-3} compared with 3·514 g.cm^{-3} for natural diamond.

Initial tests of these crystals made at the Laboratory using X-ray powder methods showed encouraging results. Unequivocal confirmation that they were diamond was obtained by two independent authorities on different single crystals. We are indebted to Dr. Judith Milledge of University College, London, and Dr. Bland, Plastics Division, I.C.I., Ltd., for carrying out the single-crystal rotation work. The latter's analysis revealed that the dominant pattern corresponded with that of natural diamond, with weak subsidiary lines corresponding to a small twin of the main diamond. There was also another pattern corresponding to a cubic single crystal parallel to the main diamond but with a different lattice spacing. This was consistent with a solid solution of carbon nickel, richer in Ni than Ni_4C.

4.4. *Further Developments.*—Considerable interest is now being shown in the high pressure field and intensive research is being carried on in many laboratories throughout the world. The reason for this activity is that the development of equipment for producing high pressures has opened up a new dimension for investigations in many areas of scientific research. For the engineer, metallurgist and physicist, high pressure investigations will undoubtedly give a clearer understanding of the properties and behaviour of materials and will lead to the production of many new materials. In this country, ultra-high pressure work is also being carried out at the National Physical Laboratory, using ultra-high-pressure as a tool to study the properties of substances, whilst at N.E.L. the current research is being devoted to the production of new materials likely to have industrial applications.

Much can be learned about the production of new materials from the synthesis and unique properties of diamond. Its great hardness has lead to its wide use in machining operations so that it is now indispensable to any industrial nation. A great deal has still to be learned about its synthesis, particularly in relation to crystal size and quality. The strength of diamond lies in the strength and high symmetry of the individual bonds between atoms. In the search for other high pressure materials with comparable hardness, consideration is being given to possible binary and ternary compounds with diamond type lattices. Among the lighter elements in the Periodic Table, the bonding in such compounds would be exceedingly strong since the inter-atomic distances should be very small, as in diamond. One such compound, a very hard cubic boron nitride, has already been synthesised in the USA.

The present ultra-high-pressure research at N.E.L. is devoted to a study of the feasibility of the synthesis of new substances and an examination of their properties. Diamond is a prototype of these materials and its synthesis was a necessary preliminary to our research programme.

Futher details of all aspects of high pressure research may be obtained on application to the Director, National Engineering Laboratory, East Kilbride, Glasgow, by whose permission this article is published.

(Photograph by Mr. J. Andrew, Plastics Division, I.C.I., Ltd.)

Fig. 13—Synthetic diamond produced by NEL. ×135

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The Compound Locomotive in France

By EDWARD H. LIVESAY

IT was often said in the decades preceding the second world war, and possibly with a certain amount of truth, that locomotive design in Britain might have shown more originality and made greater progress but for the fact that the country was endowed with plentiful supplies of good, cheap coal. To state categorically that this legacy enabled conservative locomotive engineers to gloss over a multitude of sins is perhaps over-severe, but there is little doubt that it did make it less necessary for them to acknowledge and repent of some of their faults and may have justified in some degree a tendency to "leave well alone," even when evidently it was none too good. This preamble leads to the query: Why was compounding largely abandoned in Britain, almost ignored, in the early 1900s, save for the very successful three- and four-cylinder Smith system engines on the N.E. and Midland lines, a certain number of more or less experimental machines on other systems, and a definite trend towards two-stage expansion in Northern Ireland? Yet this was so; despite the indisputable success of compounding in France and other Continental countries, it never "took hold" in Britain after Webb had done his worst with it on the North Western. Later, why was it never taken up seriously in the immediate pre-second war period, by which time the compounds of Chapelon, Collin and other French engineers had demonstrated beyond a peradventure their super-efficiency and power? These and associated questions were often asked in those days by students of locomotive design, without, it seemed, really satisfying explanations being forthcoming, though some were advanced. Even in totality, they were hardly sufficiently cogent to warrant the negative attitude generally taken, and the reluctance of designers to profit by the example set by less conservative foreign engineers. British locomotive designers were sometimes excused for reluctance to give compounding serious consideration on the ground, frequently advanced, of its complication, yet at the same time they showed no objection to multi-cylindered simples, which to all intents and purposes were as intricate and costly to build and maintain as, for example, the French compounds. Personally I plead guilty to having indulged in some carping criticism myself, and also at failing to arrive at a satisfactory solution of the apparent obtuseness of home engineers, and their inability to read, mark, learn and apply the continental lessons—until I went to France to study things on the spot, made intimate acquaintance with these wonderful compound engines, rode thousands of miles on their footplates, saw the work they were doing day in, day out, finally—and this is of very great importance—studied the humanities of the matter; that is, the men who cared for the engines in the shops, and handled them on the road. Then the mystery was a mystery no longer, at any rate so far as the French share in the problem was concerned. In France the compound was clearly logical and inevitable,

Fig. 1—Super-Pacific, Class 231-E, S.N.C.F.

and had been taken to the ultimate peak of development. In the following article an attempt will be made to justify this statement —with the invaluable help of M. André Chapelon, which is gratefully acknowledged.

While there may have been several reasons of more or less validity for British objections to compounding, two of major importance emerge to account for it, and for the Gallic preference for the system. The first was that in Britain, until the second war, coal was both cheap and good, which was not the case in France. Without running the suggestion into the ground, seemingly it mattered little in those days that coal was squandered by British locomotives—and it often was. An engine blasting along with a substantial amount of the fuel soaring 50ft into the air unburnt was so common a sight as to cause little comment ; it might even result in some degree of admiration ; it was spectacular, impressive, but decidedly wasteful ! This sort of thing was frowned upon across the Channel—and still is—there, coal is fed into a firebox to do useful work, not to produce a pyrotechnic display at night, nor deprive the chauffeur of his bonus by day. In a word, fuel economy has always been regarded as of first importance in France, and undoubtedly compounding was one way of achieving it. The second reason, probably of even greater direct causation, was that in general French locomotives were called upon to do harder work than their British opposite numbers—the loads hauled were greater, speeds were as high, and often higher, so the demand for power was correspondingly more insistent. Granting these premises—fuel economy and heavy loading—it follows that compounding was fully justified in France, but was not so vital in Britain ; " simples can do the work here—let well-enough alone ! "

It is admitted that this emphasis on the greater loads hauled in France is not to be regarded as a law of the Medes and Persians ; in both countries there are exceptions to the rule ; the statement concerns average, not extraordinary, loads. Generalising, in France express trains are likely to be few and heavy, just as they are in Canada or the States ; in Britain, in comparison, they are more frequent and lighter. Judging from my considerable experience of the S.N.C.F. during the last few years, the average weight of a French express train is in the neighbourhood of 500 tons ; of a British express, 300 tons ; these average figures cannot be far out. " Flying Scotsmen," " Royal Scots " and similar 450/500-ton trains are not " average," but above it. *Per contra*, I have travelled about France with at least a hundred trains, generally on the footplate, covering many thousands of miles, and in my recollection the trains generally weighed from 500 to 700 tons ; on occasion, 800, and freight trains were 2000 or more. All the speeds were well up to the British average, the freight trains—air-braked—running at 40–45 m.p.h. With these respective British and French figures, it follows that a British express engine, simple, running on a 15 to 20 per cent cut-off, is using steam as expansively as is necessary and obtainable in one-stage, and the terminal exhaust pressure will be moderate. A French engine, however, with a 700-ton train, supposing it were a single-expansion machine, would be working with a cut-off of 30 to 40 per cent, even more at times, and exhausting at a very high pressure ; I will not " chance my arm " by saying just what it would be, but it would certainly be such that two-stage expansion would obviously be well worth while ; therefore a pair of l.p. cylinders is generally provided. Summing up, in France very heavy demands are frequently made on locomotives, but in Britain this is far less frequent, and simples can do all that is required. At any rate, this was certainly the case before the war, when British locomotives were at the peak of their form, well cared-for in the shops, and burning good coal, much better than was generally the case in France. With British engines seldom needing to be " thrashed," single-expansion could do the work well enough before the war, but we all know things are different nowadays, when coal is very apt to be of poor quality, and alas ! firemen are not much better, though this is not their fault. Unfortunately it is too late now to stem the rot which has set in ; the steam locomotive has had its day, and is getting less and less consideration in the shops and on the road. Diesels and electrics will soon reign in its stead, and daily the change-over is taking place ; though judging from some recent happenings the public has had reason to wish that haste had been made a little more slowly.

Chapelon and the compound locomotive —the two are synonymous, and the association between them goes back many years. The principles M. Chapelon advocated, and has since consistently applied, were first put into practice not so much with new locomotives as originally designed as with existing engines which, though excellent in the light of the knowledge of their day, were considered by M. Chapelon to be far less efficient than they should be. To these, during rebuilding, his principles were put into practical shape, and at once the truth of his theories and the value of the resulting improvements became evident, the efficiency of the reconstructed engines being greatly increased, to a degree beyond expectation, as to be on occasion almost incredible. It was with these engines, both the reconstructed machines and those built to the same improved design shortly before the war, that I have made contact at Calais when visiting France during recent years, and on which I have ridden to Paris (Fig. 1).* The rebuilds were approximately forty years old ; the others, new in the mid-thirties, had been reconditioned after suffering war-neglect or worse, yet the performances of all were so admirable that it was impossible to detect any difference between the two groups; they all behaved as if just out of the shops. They have been dealt with fairly thoroughly in previous articles, and their chief features described, so in this article the ground will not be covered again in entirety, but it is fitting that something additional should be set down, as not only has considerable fresh information been obtained from M. Chapelon but it is probable that the happy association between the locomotives and the writer will soon come to an end—if in fact it has not already done so—both they and the writer will have become redundant, and we shall go into retirement together ! Already these outstanding engines no longer run right through from Calais to Paris on the " Fleche d'Or " and other trains, but only as far as Amiens, where a soulless electric locomotive takes over and carries on into the Gare du Nord—to me an anti-climax ! Recently, pondering over my experiences with these very attractive engines, I approached M. Chapelon for enlightenment on certain features of their design not quite clear to me—how and why various things came about, and the effect they had ; things evidently not clear to others beside myself, judging from theories advanced at times in THE ENGINEER. I also asked if he would be good enough to touch briefly on the series of advanced designs of locomotives which had been planned for post-war construction, but which unfortunately were never built, due to the electrification and diesel " Autorail " policy adopted by the S.N.C.F. I also requested that he would kindly clear up one or two points regarding the 4–8–4 express locomotive " A1," the

*The chief dimensions of both these classes, as reconstructed and built in the 'thirties, are :

Cylinders (two) h.p., outside	16½in by 25½in
Cylinders (two) l.p. inside	25½in by 25½in
Cylinders ratio h.p./l.p.	1/2·32
Wheels, driving	6ft 5in diameter
Weight :	
On drivers	56·25 tons
Engine	100·15 tons
Tender	77 tons
Boiler	5ft 6in by 19ft 4in
Centre from rail	9ft 4in
Heating surface :	
Tubes, flues and firebox	1988 square feet
Superheater	784 square feet
Steam pressure	246 lb
Grate area	46·5 square feet
Coal	9 tons
Water	7700 gallons

A.C.F.I. feed-water heater
Nicholson syphon.
Dabeg poppet-valves

prototype three-cylinder Smith-system compound on which to some extent the design of the post-war machines was based, a machine that had done remarkable work, and represented a complete breakaway from traditional four-cylinder French practice. I had spent several hours looking round this fascinating engine at Le Mans some years ago, as was described in THE ENGINEER of May 21, 1954. M. Chapelon's response to these requests was so generous, and given at such length, that—coming from such an authoritative source—it was almost obligatory for me to share it with others, instead of keeping it to myself, and so it is given in full herewith. But it is necessary to explain that his thesis is based to some extent on a misunderstanding of the term " reinforced compounding " which was used in my request and was rather prominent in it—he interpreting it as meaning " reconstructed compound "—that is, the rebuilding of the original " Pacifics," rather than the way they are handled on the road. However, this " derangement of epitaphs " has brought about a most informative dissertation, in itself of much value, and gave me the excuse to approach him again for further enlightenment, which resulted in another interesting letter, quoted in its turn. I must add, in justice to the individuals concerned with the translation,† that the rendering of technical French into literal English is not only difficult but often impossible, and allowance must be made for this ; though the script has been kept to as closely as translation will permit, occasionally the meaning is not too clear. (The words in parentheses are mine, and are inserted with the best intentions—to clarify.)

Paris,
December 27, 1960.

" Dear Mr. Livesay,

" . . . I believe that by ' reinforced compound ' you mean ' modified compound ' (*rebuilt*) according to the principles applied to the prototype which was No. 3566 of the P-O Railway, turned out by the Tours workshop in November, 1929, thirty-one years ago, of which the 231-E Nord engines, which you know well, are exact reproductions.

" If the present officials (*of the S.N.C.F.*) seem to have lost interest in these rebuilt machines, of which there are 1500 more or less completely built or rebuilt according to the same principles, and still providing important services on the S.N.C.F., it is because the fashion is now in 50-cycle electrification on main lines, and in rail-cars elsewhere, since steam traction is now anathema to up-to-date brains. For these (*to these people*) steam is despicable, and something to be ashamed of.

" Nevertheless, the principles of our rebuilt machines are by no means antiquated, since they are essentially scientific, and have shown outstanding value on a large experimental scale. Had the S.N.C.F. not changed its policy in 1945, these principles would have found their full application in a group of 6000 h.p. engines entirely standardised, suitable for all services, and of the three-cylinder compound type, the excellence of which, so far as sturdiness and efficiency are concerned, had been demonstrated by No. 242-A1 rebuilt along these lines. These machines would offer for the first time the high thermodynamic efficiency of our (*French*) engines, combined with the high mechanical efficiency and minimum maintenance costs of the latest American Solutions (*productions*, *types*) with frames cast in one piece, roller bearings and mechanical stoking.

" The 141R (*American*), at least the latest of these, equipped with these American improvements, were immediately appreciated by motive power services (*departments*) in spite of their excessive fuel consumption, 50 per cent more than the 141P (*French four-cylinder compound*), and have accentuated the contrast with our old European designs, causing a certain amount of discredit to accrue to our French machines.

" We had clearly realised this a long time ago, and it fully justified the combined programme we had conceived and proposed, a programme which was widely approved during the war by the Public Works Department, but rejected by post-war administrations as too old-fashioned for the twentieth century, the era of electricity, diesel and atomic energy.

" The principles on which the rebuilding of our compound machines are based are extremely simple, and are derived directly from experience. The power developed by our ' Pacific ' machines compared with that of the former ' Atlantics ' was downright deficient in spite of a grate-area 4·27 square metres as against 3·10 square metres.

" Indicator diagrams taken from the h.p. cylinders of these ' Pacific ' machines showed that with h.p. cylinders equipped with piston-valves, very important throttling occurred which limited their power. Further, exhaust back-pressure considerably reduced the area of the l.p. indicator diagrams at high speeds.

" A first remedy immediately appeared—increase the area of the exhaust passages in the motor group (all four cylinders).

" A second remedy had to be looked for in the improvement of the exhaust exit (*blast-nozzle*). By reducing these losses it was possible to bring the indicated horse-power from 2000 to more than 3000. In order to do this it was necessary to double the outlet sections (*area of pipes*, &*c.*) from regulator right through to final l.p. exhaust —that was done.

" Then the existing Nord or Clover PLM exhaust (*blast pipe*) was replaced by a Kylchap which had just been perfected on the system, and which enabled us, for the same draught in the smokebox, to halve the counter-pressure above the exhaust pipe at low speeds, and by two-thirds at high speeds. Thus 3400 i.h.p. was obtained in cylinders of unchanged volume. Expansion in the cylinders being thus obtained according to a law much closer to the adiabatic, the rate of irreversibility of the cycle having been considerably reduced, it was logical to increase the degree of superheat so that it was still dry at exhaust, and much more so (*it was logical*) as with existing Schmidt superheaters the l.p. cylinders were already working with saturated steam. It was then decided to increase the superheat from 300 deg. Cent. (636 deg. Fah.) to 400 deg. Cent. (848 deg. Fah.) by enlarging the superheater, and in order not to lose anything on the transmission efficiency of the boiler, a Nicholson siphon was installed in the firebox ; this siphon had a major advantage of increasing efficiency at low speeds, and the ability to raise the water-level very quickly after a severe demand (for steam), when the regulator is closed ; at the same time the increase of pressure is sharply accelerated (*steam is raised quickly*).

" Since, on account of the considerable increase in the degree of superheat then planned, difficulties with the lubrication of the cylinders were anticipated, it was decided to apply these improvements to one of the two ' Pacifics ' on which it was intended to fit Lentz (*poppet oscillating cams*) valve-gear to the existing Walschaerts distribution. But of course the entire cylinder group was studied again in order to increase the steam outlet sections (*ports*, *passages*, &*c.*), as the application of the Lentz distribution system first planned and studied by Paxman of London (at the time license holder of the Lentz patents) involving valves giving nearly the same sections (*port openings*) as the existing slide-valves had given pretty poor results during trials. (These trials were made in March, 1927, after studying the cylinders of the new machine, the drawings of which had been prepared in November, 1926.) At the same time, the valve-gear brought about considerably reduced moments of inertia affecting the l.p. mechanism, and consequently the wear and tear at high speed, especially with increased steam outlet sections.

" So far as motor (*cylinder*) efficiency was concerned, ample area exhaust valves obviously did not contribute anything, but—and this is an essential point—they reconciled large area valves with high speed and the highest degree of superheat without any lubrication disadvantages.

" The part played by compounding in the success of these alterations has been outstanding, since it overcame the disadvantages caused by cylinders with big outlet passages (*and blast-pipe orifice*). Indeed the increase in sectional area of these passages, valves, &c., may result in increased losses due to leakage, losses that can be very important, and can more or less neutralise the good resulting from reduction of throttling (*constriction of exhaust*).

" Now, thanks to two-stage expansion, the pressure differences under which the exhaust is produced are much weaker (exhaust pressure is lower) than in a single expansion machine, the exhaust to the l.p. cylinders being entirely lost (*for blast purposes*), since it is used in the l.p. cylinders. On the other hand, all things being practically equal, the exhaust pressure from a compound engine is only half as much as in a single expansion machine of equal power. This advantage is obviously independent of the question of wall action (*condensation*), and is unaffected with superheated machines.

" Losses through clearance-spaces, the volumes of which are increased by large steam passages, are effectively offset by compounding, in which only steam at reduced pressure is lost, while the steam in the intermediate receiver represents in weight less than half the loss in a single expansion machine where clearance spaces are filled by steam at boiler pressure. This advantage is still independent of the phenomenon of wall action (*condensation*), and continues to exist with superheated machines.

" That is not all. In the compound, for the same power developed as in an equivalent single expansion locomotive, the rates of admission (*cut-off*) for h.p./l.p. volume ratio of 2·0-2·5 are about double those of a single expansion locomotive ; throttling (*wire-drawing*, &*c.*) is thus reduced, since port-opening increases with the degree of inlet (*degree of cut-off*). *With equal exhaust areas*, the compound machine has therefore lower losses through throttling than an equivalent single expansion engine, provided, of course, that the situation has not been jeopardised by constricted h.p./l.p. connecting passages. That is another advantage remaining with superheated machines.

" Furthermore, lengthening the admission of the l.p. cylinders in relation to what happens in an equivalent single expansion engine reduces the exhaust advance, thus causing smaller loss by the expansion, and lower steam pressure on the opening of the exhaust ports, reducing the force of the exhaust ' puff,' which in turn reduces the

† Principally Mr. Louis-Herbert Desjardins, of the Press Relations Office, C.P.R., Montreal, to whom I am much indebted.

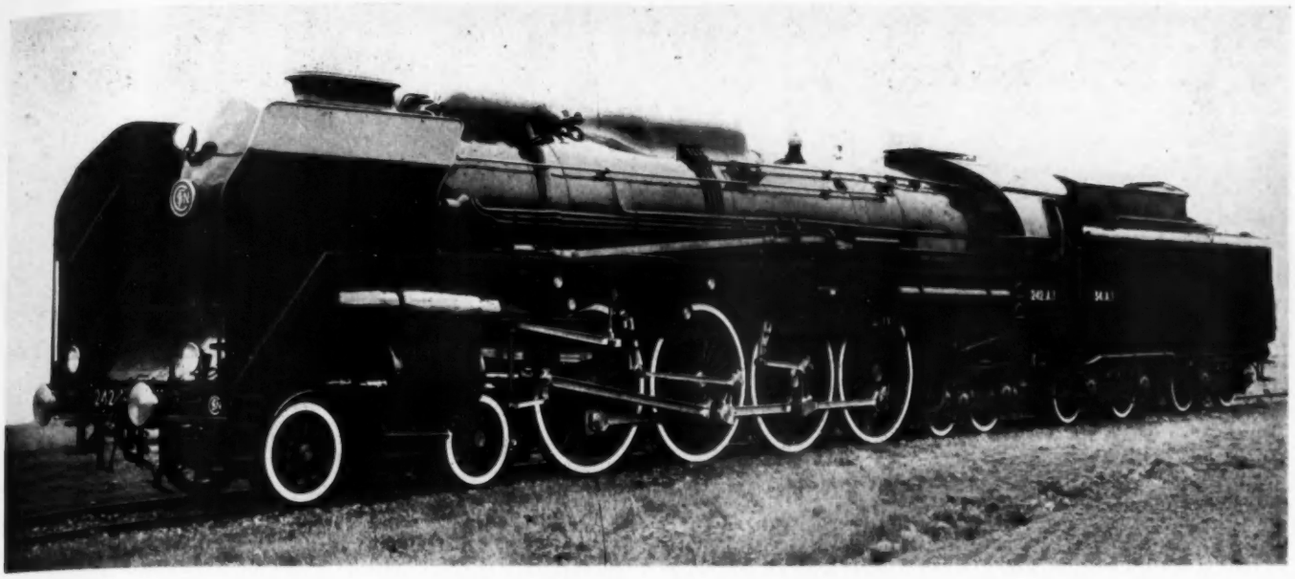


Fig. 2—Three-cylinder, compound express locomotive No. 242-A1

dragging of ashes (and unburnt fuel through tubes), and results in better combustion on the grate. These advantages (especially the latter which is of great importance particularly at high speeds) still remain with superheater machines.

"The reality of these considerations is such that when it was attempted to fit single expansion machines with improved motors, the failure has been a systematic one, because it had been forgotten that success depended not only on the quality of the motors and boilers, but also on a rational association of boiler, motor and an adequate *exhaust*. The steam engine is a whole in which each organ has to fulfil the needs of the others ; that is a perfect outline of what one has to create, and not (*merely*) to achieve a number of organs which, although excellent in themselves, interfere with the working of organs associated with them. The bad results given by Stumpf system machines have been a striking example.

"Recent attempts made to apply the principles of No. 3566 P/O to single expansion machines have once more given proof of these truths. That is why, in order to improve these machines it is necessary to take greater precautions than with the compound machine, and in particular, to study with special care the cylinders in order to avoid increasing the clearance space, and modify the exhaust flow ; this we have achieved very simply in (*poppet*) valve machines by modifying the cam contours, and in slide valve machines by modifying the shape of the ports on the exhaust side. We have thus succeeded in reducing the force of the exhaust beats, which force was all the greater as the ports open more widely ; we succeeded in retaining on modified single expansion machines about the same coal and water saving ; such as 'Mikado' No. 141-113 of the Western Region which gave us on the Paris–Caen line when hauling express trains of about 600 tons an average water saving of 22 per cent, and coal-saving 24 per cent. On an up-grade of 7 per 1000 with 608 tons the engine maintained 69km.p.h while developing 1865 h.p. with 30 per cent cut-off and 368 deg. Cent. (694 deg. Fah.) superheat. A non-rebuilt of the same type with 648 tons went up the same grade at 63km.p.h. and 315 deg. Cent. (599 deg. Fah.) superheat, developing 1678 h.p. with a cut-off of 50 per cent.

"Thus, single expansion machines can also benefit more or less completely by the improvements made to No. 3566 when the necessary steps are taken, without, however, reaching the efficiency of the compound for the reasons expounded above.

"In addition to the failure of Stumpf distribution machines where the anticipated coal and water saving was destroyed by the force of the exhaust beats, there is the example of the latest British Railways 'Pacific' with three cylinders and Caprotti distribution, a machine the motor of which has been proven *excellent*, but whose fuel consumption has been excessive, and the efficiency of the boiler having been proved mediocre in spite of its large size ; all this, obviously, on account of one of those causes we well know, the exhaust problem, this being one of the most important involved in the operation of the steam locomotive.

"I hope, dear Mr. Livesay, I have answered your questions, but I remain at your disposal to give you any other information you might wish to have. As you know, the locomotive is my avocation. I am now putting the last touches to an entirely new steam engine theory on which I have been working for many years ; it accounts pretty well for the complex phenomenons to be found in the operation of this outstanding thermic engine, which in spite of its present detractors (who are no doubt insufficiently informed, and unconsciously carried away by the wind of modernism), will always remain the Locomotive, the masterpiece of Stephenson and Seguin.

"Once again, my best wishes to you.

A. CHAPELON."

M. Chapelon's dissertation is so clear and detailed that it can well be allowed to speak for itself ; I will merely draw attention to one or two outstanding points.

(1) The attainment of thermodynamic efficiency not merely by compounding, but by the use of high-steam-pressure and superheat temperature.

(2) The necessity for ample steam-pipe areas right through from regulator to final exhaust-nozzle, coupled with large valves and steam-passages.

(3) The very great importance of low exhaust pressure—he mentions this more than once, laying great stress upon it. His past investigations into this problem resulted, of course, in the Kylchap blast-pipe and chimney, in twin and triple form—the former recently adopted on a considerable scale in Britain, instead of in the pre-war half-hearted manner.

One wonders—or at least I do—how many tens of thousand tons of coal have been wasted by "Kings" and "Castles" during the thirty-odd years they were running without adequate superheaters or Kylchap blast-arrangements ? Was all that time really necessary to discover the advantages of both devices ? Surely it was common knowledge long ago.

In past articles on French locomotive experiences attention was frequently drawn to the high degree of superheat which on occasion reached 800 deg. or more ; this was so high that I sometimes rather wondered if the gauge was not handling the truth somewhat carelessly, but from M. Chapelon's statement it will be seen that it was not accidental at all but of intention—he mentions 848 deg. Fah. as the objective. The same with softness of exhaust, which often impressed me even when engines were working really hard ; that too was not solely the result of two-stage expansion, but of carefully planned blast and chimney-gear. The converse was noted once from the footplate of a "King" taking 360 tons of "Cornish Riviera" up 1 in 36 into Dainton tunnel, just beyond Newton Abbott, where, notwithstanding a "jumper" blast-nozzle, the exhaust was a bang rather than a puff, and it was not surprising to find the roof of the tunnel under repair. A good deal of power must have been expended in blasting those bricks loose ; according to M. Chapelon's dictum it might have been used to better advantage in another pair of cylinders.

In both this article, and M. Chapelon's letters, there are several references to the three-cylinder compound 4–8–4 express locomotive "A1" (Fig. 2). This unique engine, the only "Smith system" compound built in France in recent years, represents a complete break-away from the traditional de Glehn four-cylinder type ; moreover, it was built to serve as the experimental prototype of the advanced Chapelon designs which were to have been adopted after the war, and would have been built but for the subsequent decision to electrify and "dieselise" the whole railway system. This engine, probably the most powerful express locomotive in Europe, did a great deal of experimental test running during immediate post-war years, putting up remarkable

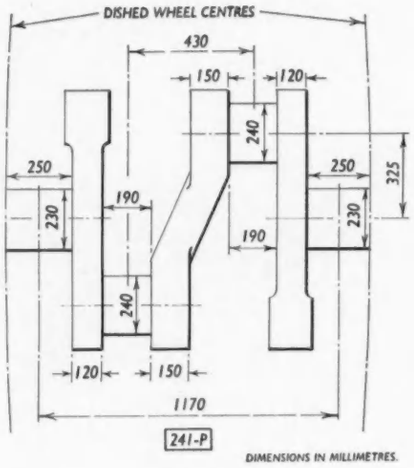


Fig. 3

Fig. 5—Three-cylinder, simple 4-8-2 express locomotive reconstructed as A1, three-cylinder compound

performances, but never went into regular service. I had the pleasure of spending several hours round, on and under it at Le Mans in 1952,‡ where alas, it was in cold storage, and has remained, I imagine, ever since. It was intended to inaugurate what would have proved a new three-cylinder era for the French compound, and I approached M. Chapelon on various occasions for information about it, which he readily supplied ; he does so again in the following letter. In this he confirms what I have suggested in previous articles, that the paramount reason for the adoption of the three-cylinder system of compounding was not the hoped-for attainment of higher thermal efficiency, but simply to obtain room for adequate bearing surfaces, crank and journal, on the h.p. driving-axle, which it was difficult to do where there were two large inside h.p. cylinders, the associated double cranks and

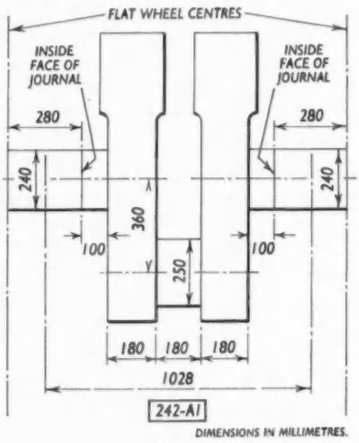


Fig. 4

four webs taking up too much space. The two sketches (Figs. 3 and 4) replicas of M. Chapelon's, dimensioned according to his drawings, bring this out ; they apply to the four-cylinder " P-class " and the three-cylinder " A1 " respectively. M. Chapelon's letter states—contrary to opinions often advanced in England—that the thermal advantage of the three-cylinder system over the four-cylinder is so small as not to be worth consideration ; nor evidently was greater simplicity a deciding factor, coupled as this necessarily is with inferior balance—increased bearing-surface and strength were the over-riding considerations. Most of the foregoing applies, of course, chiefly to very powerful engines ; there is room enough where the cylinders are of moderate size or power, but " A1 " and its planned successors were decidedly powerful machines, 4–5000 h.p. The single inside cylinder of " A1 " 24in by 28·8in developed 1900 h.p., and the twin inside cylinders of the " P-class " are 17·7in by 26in., the pressure in both cases being 290 lb. Adequate bearings could be provided for the former, but apparently not for the latter, despite dishing of the wheel-centres.

Before coming to M. Chapelon's second letter, a brief description of " 242-A1 " and its history is apropos. It was a rebuild and enlargement of a simple three-cylinder 4–8–2 express locomotive (Fig. 5) turned out in 1932 by the Fives-Lille Company, to handle the heavy Cherbourg–Paris boat trains, which were timed to cover the 236 miles non-stop in 240 minutes. They were the first three-cylinder simple express engines to be built in France, were mechanically stoked, the drive was divided, the inside cylinder, 22½in by 25½in, acting on the first coupled axle, and the outside cylinders, 20½in by 30in, on the second. Renaud poppet-valve gear was fitted, and the steam pressure was 290 lb ; the heating surface totalled 2890 square feet, plus 997 square feet from the superheater, the tubes being mostly of the Serve ribbed pattern ; the grate area was 54 square feet. The coupled wheels were 6ft 4½in in diameter, and the tractive effort 55,000 lb from which stems one thing open to criticism—the very low factor of adhesion, only 3·15, which one would think sure to prove inadequate if the engine were " opened out " to develop its 2800 h.p. continuously, under any and every rail condition. The engine's weight was

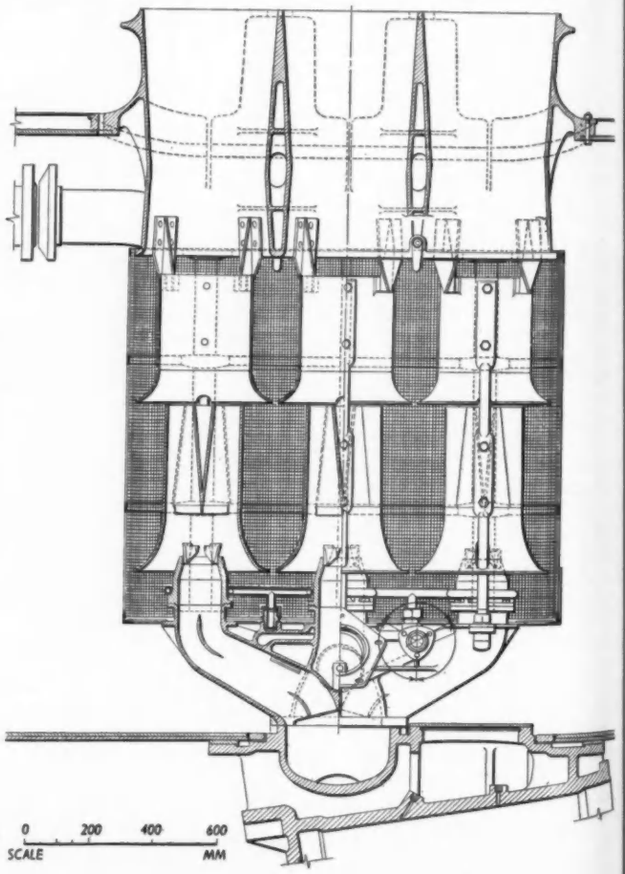


Fig. 6—" A1 " triple Kylchap exhaust pipes and chimneys

‡ The Engineer, May 21, 1954.

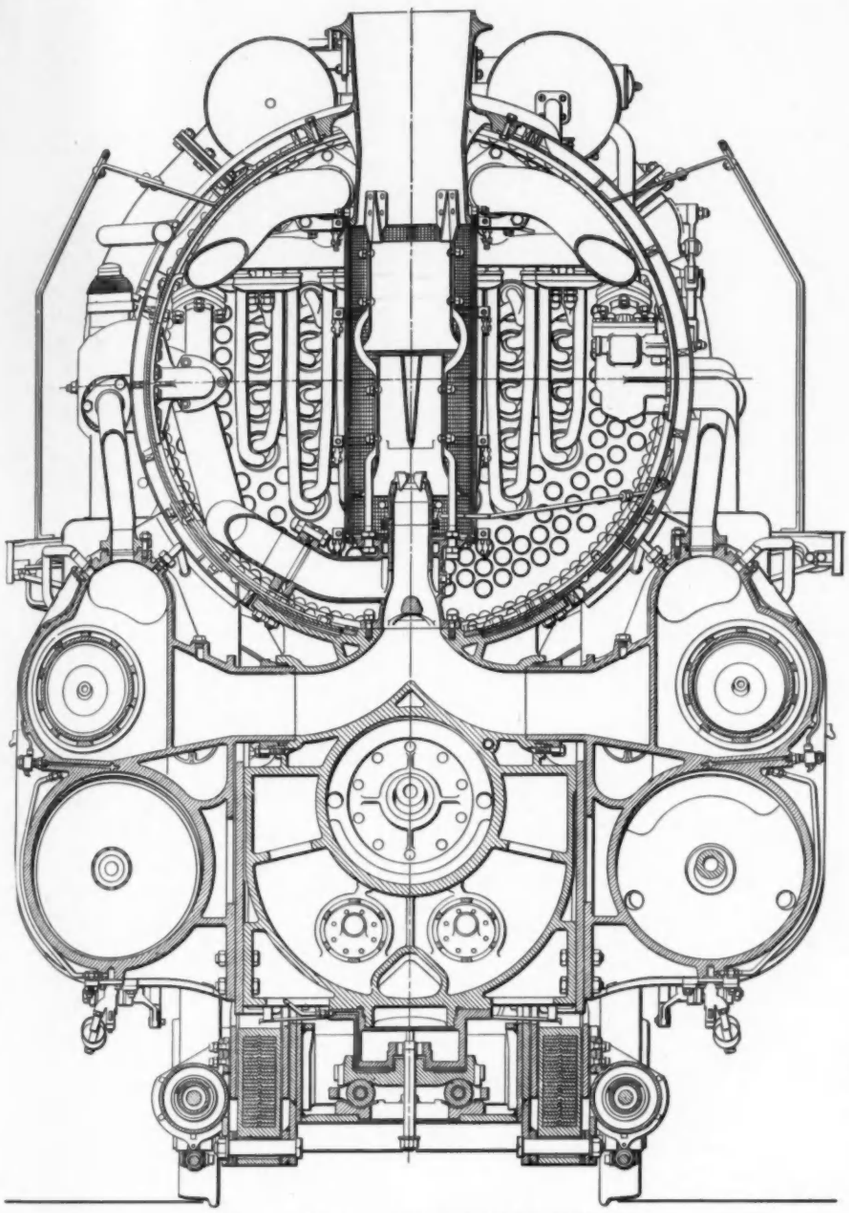


Fig. 7—" A1 " smokebox and cylinder details

128 tons, of which 77 tons were available for adhesion ; the tender, running on roller bearings, weighed 77 tons, and carried 7500 gallons of water—there are water-troughs on the Paris–Cherbourg line. The engine had the A.C.F.I. feedwater-heating apparatus, Leach air-sanding gear, automatic train control, and of course Westinghouse brakes.

Reconstructed, it became " No. 242-A1," a 4–8–4 three-cylinder compound, the adoption of a four-wheel trailing truck becoming necessary because of considerably increased weight, 20 tons, due to a strengthened frame and heavier firebox, embodying steel in place of copper, and two Nicholson syphons. The single inside h.p. cylinder, 24in. by 28·8in, still drove the first coupled axle—on the " P-class " four-cylinder 4–8–2 machines, the two h.p. cylinders drive the third axle—and the two outside l.p. cylinders, 27·2in by 30·4in, the second. The Walschaert-actuated valves are of the Willoteaux double-port type for the l.p. cylinders and Trick for the inside one, the latter being worked by a return crank seen on the left-hand side of the third driving axle in the photograph. The Houlet superheater gives a temperature of 850 deg. Fah.; the tube and firebox heating surface totals 2720 square feet, and the superheater area increased to 1294 square feet, the grate area remaining 54 square feet and the pressure 290 lb. The adhesion weight became 84 tons, and the total engine weight 148 tons. The arrangement of the exhaust passages and outlets, the importance of which is so emphasised by M. Chapelon, is shown in Figs. 6 and 7 ; the nozzles are variable.

Typical of the engine's performance is the following test-run made over the exceptionally heavy route from Lyons to St. Germain-des-Fosses, one of the most severe in France, as the profile, Fig. 8, shows. " A1 " was at the head of a train weighing 611 tons, and gained 34 mins. on a schedule of 3 hrs. 27 mins. for the ninety-three miles (approximate), making the actual time 2 hrs. 53 mins., and the average speed 32·4 m.p.h. At first this does not seem very impressive, but look at the profile—bear in mind the load, 611 tons—and a speed limitation of 65 m.p.h.—together they put a very different complexion on it. During the run the maximum power developed was 4200 h.p. at 56 m.p.h. on a gradient of 1 in 90—the factor of adhesion seems to have been sufficient on this occasion, at any rate !

It is indeed a gruelling test for a locomotive, single-handed, to take a train weighing 611 tons up a gradient of 1 in 39, which is practically the same as the Lickey and Dainton pitches ; on the latter a " King " was limited to 360 tons, and on the former a very moderate train called for at least the six-cylinder 2–8–0–0–8–2 " Garratt " as pusher. I have been over this St. Germain-des-Fosses–Lyons line on a Chapelon 2–8–2 four-cylinder compound (THE ENGINEER, August 31, 1956), and was very much impressed by the fine work done on this exceedingly severe route, quite one of the heaviest I have ever travelled over. Even in the Rockies the maximum gradient is now only 1 in 44, on which the great 2–10–4s were limited to 600 tons.

An acceleration-test train of 604 tons reached 62 m.p.h. on the level from standstill in 3 mins. 10 secs. (figures taken from the *Locomotive*).

On entering the cab of this exceptionally interesting engine I was immediately struck by the multiplicity and complexity of the fittings and controls spread over the whole of the frontal area, and at the sides too—in fact, any place where room could be found for this or that indicative dial, gauge, wheel, pipe or lever. It was bewildering ; no driver, it was evident, could possibly consult or manipulate all these things, while at the same time giving due attention to his regulator, reverse and so forth, and simultaneously watch the track and signals. But then it occurred to me—this was really an experimental machine, from which a variety of lessons would be learned, to be embodied in engines then only on the drawing-board. This display of dials and gauges was chiefly for the benefit of officials and experts taking notes of everything that happened from one end of the engine to the other—including, of course, M. Chapelon himself !—they were not provided for the delectation of the enginemen under ordinary running conditions. If I had had the good fortune to travel on " A1's " footplate I would certainly spend at least a preliminary day studying all this gear, as, failing this and understanding it, I should certainly miss a great deal of what was happening, and much of the engine's potentialities and performance would go unrecorded. I thought too of what an

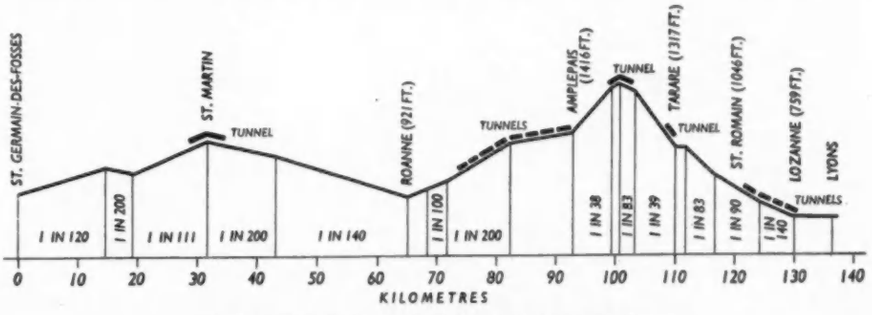


Fig. 8—Gradient diagram St. Germain-des-Fosses to Lyons

English driver's reactions would be on getting into that cab—even what he would say in the vernacular—but this is a serious journal, so better not recapitulate.§

No. 242-" A1 " having been briefly described, we now come to M. Chapelon's exposition of the reasons that led to its construction, and the discarding of the traditional de Glehn four-cylinder system.

He explains :

Paris,
February 22, 1961.

" . . .Please excuse me for not having understood the expression ' reinforced compound,' and moreover for not knowing that this is in fact a (*common*) English expression. Here is my reply to the questions that you have asked me.

" (1) The arrangements that permit ' reinforced compound ' working are those determined by the starting (*necessary for*), and which include a valve or small regulator operated by the mecanicien permitting the introduction of live steam to the intermediate reservoir so that connection is effected between the cylinder (*l.p.*) and the regulator assuring direct automatic introduction (*of steam*) when it (*the piston*) is near the end of the stroke, there also being some special ports drilled in the base of the regulator (*l.p.*) and communicating with the h.p. admission ; these ports are not effective until the handle (*main regulator*) passes 60 deg.

" As you can see, the live steam is generally introduced into the intermediate reservoir (*l.p. receiver*) and not into the steam cylinder itself.

" (2) Working ' reinforced compound ' has never been used in a normal way in France. It has no identity because we have never had recourse to it ; for example, on a machine with large wheels normally attached to a freight train, the speed is not permitted to drop to zero on a steep grade. Obviously I do not speak of the starting of machines which do not have this derivation (generally PLM), and where they are forced during many turns of the (*driving*) wheels to work ' reinforced compound.' We do not wish to say that this arrangement has been abandoned, as it is always possible on all machines which have a valve (*regulator*) for direct admission of live steam to the intermediate reservoir ; such is the case with all ' compounds ' which do not have a self-starting arrangement as on many two-cylinder compounds. Where the compound has a regulator for supplementary admission of steam to the intermediate reservoir, it is interesting in exceptional cases to note the effect on traction of the machine (for example, some Americans prefer the Mallet compound for graded lines, and of simple design for level lines), it is not economic because the rendering (*value, result*) of the thermodynamics of the live steam is withheld without the work of the pressure of the intermediate reservoir (*receiver*), and results in an inferior force half of that in the compound cylinder.‖

" (3) I prefer the three cylinder compound to that of four cylinders in examples (*engines*) of great power because the axle (Fig. 4) presents a more robust unit with only one crank than with two cranks (Fig. 3) as the the experience of our French compounds has well demonstrated. With ' Atlantic ' or ten-wheel machines we have not had any occurrence (*difficulties*) with two cranks, but with ' Pacifics ' the trouble has occurred, and we can safely say that the crank-axle was the only poor one (*part*) in service on these machines. Thanks to the balanced built-up axles, also being as thick as possible, the situation has ameliorated itself without becoming entirely satisfactory, particularly on the compounds on which the pressure in the intermediate reservoir was too low, and where the forces of inertia (*large l.p. pistons, &c.*) also took some exaggerated proportions.

" (4) The one-crank axle offers the advantage over one with two cranks, as you remarked, not only to permit the necessary dimensions to be used on the axle, but also results in a more rigid assembly which in particular will be less affected by the lateral thrust from the wheels on the track, which is extremely noticeable, and can bend an axle with two cranks, the result of great stresses in parts of the axle-boxes and rods (Fig. 3). The angle *L* (Fig. 9) which the

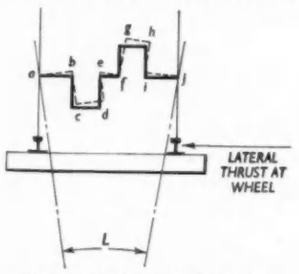


Fig. 9—Bending of crank-axle

wheels would take as a result is as large as the length of the line *A B C D E F G H I J* of the axle, and is greater than the moment of inertia of its several elements ; especially if the crank-webs are weak. It is also necessary to have as short a piston stroke as possible, and very thick crank-webs. From this point of view, the axle with one crank is much better than one of less strength and shorter (*line A–J*), and we have the necessary space to have thick crank-webs. The sketches give the comparative dimensions of the crank-axle of the 241-P (with two cranks) and of the 242-" A1 " (with one crank). The first drawing shows the ' wheels in curve ' (*with dished centres*), and the second drawing with ' straight wheels' (*flat*). We have found that the one-crank axle of 242-" A 1 " has been continually tested without any incident from threequarters of an hour to an hour at between 60 to 120km.p.h. It is not even necessary to occupy (*use*) all the vacant space between the axle-boxes, as there is an unoccupied space (*blank*) of 100mm (4in) between the crank-webs and the (*inner faces*) of the boxes.

" (5) Theoretically a compound with three cylinders should waste less (*steam*) than one of four cylinders, because the vulnerable surfaces (*walls, &c.*) and condensation are less than with the latter type, but the difference is practically negligible in practice, and we can admit, from experience that the results are the same. From the point of view of thermodynamics, if these (*walls, &c.*) are sectionally dimensioned, and conducted (*treated*) in the same manner, that is to say, with the h.p. and l.p. notches (*cut-off*) conforming in functions of this figure, the results are very sensibly the same for the three- and four-cylinder compound.

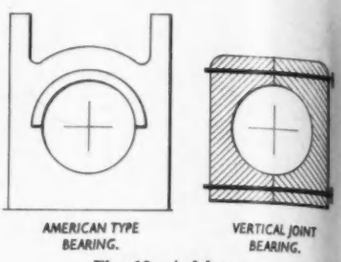


Fig. 10—Axleboxes

" During try-outs of the 242-" A1 " there were never any incidents (*faults*) concerning axle-boxes, connecting-rod or crank (*of the inside cylinder*) in spite of all the efforts that have been made to cause failure. As was hoped, this solution has been a complete success, demonstrated in a peremptory fashion (*decisive*) on axles with locomotive brakes, with continuous power as high as 4000 h.p. at the greatest speeds. No overheating has been noticed on the h.p. connecting-rod, nor in the boxes of the crank-axle. It has not been the same with the 241-P (*in the case of*), with which the systematic heating of the boxes of the h.p. axle (*two-cranked*) cannot be made normal except by the replacement of the usual boxes by vertically-split boxes used I believe formerly in England on certain machines, and which have given good results in some difficult cases in the north. (Sketches of an original American box (Fig. 10) and of a vertical joint split box are given.)

" The only trouble we have had with 242-" A1 " is normal on compounds where the h.p. cylinders are inside, because of the very great temperatures which exist there ; the difficulty of lubricating the crosshead (*inaccessibility*), and little-end of the connecting-rod. There has been a quick remedy in installing a small mechanical lubricator filled with oil. (The German railways have tried a similar system on their three-cylinder simple expansion machines for the middle connecting-rod.) It simply feeds this oil with the aid of a valve acting as a piston but operated by inertia, occupying a position of 48 deg. At the bottom of the stroke it rises (*aspiration*) and at the other end closes (*delivery*) sending the oil at each revolution of the wheel into the oil-channels of the cross-head pin, at the same time operating the piston by centrifugal force. This arrangement has given us such good results that we have extended it to the outside crossheads, the big-ends of the connecting-rods having already been taken care of. This system of piston operation of lubrication is definitely best for the small pins as it does not get out of order, and once it is properly set it is not necessary to touch it between two shoppings.

" The power acting on the h.p. connecting-rod (of 242-" A1 ") is indeed great, but in order that it be not subjected to a pressure of 20 kg per metre the starting regulator is arranged so that the pressure in the reservoir never falls below 5 kg per metre either at starting or in running. In normal running this pressure with the admission valve (*regulator*) used at h.p. or l.p., is held between 9 kg and 10 kg, so that the h.p. piston is not subjected to more than a difference of approximately 10 kg per metre.** This force is always higher than on the A4 (British), (*with which*) there should be no question of lubrication (*difficulties*) ; a detailed examination would be necessary (*to find why these have arisen*).

§ I distinctly recall the following passing through my mind too. Just before the war a certain Mr. Burgin, a Government dignitary of some sort or other—Minister of Transport was it?—made a footplate trip on a Stanier " Pacific," afterwards giving his impressions, though probably he did not know the front of a locomotive from the back. " Much too complicated," he pontificated, " should be greatly simplified." I wondered what he would have said after a trip on " A1." Probably he would have been affected in the same way as the chameleon placed on a piece of Scotch plaid—it swelled up and burst.

‖ I am aware that this paragraph is somewhat involved—at any rate to me, and probably will be to some readers—but this must be attributed to the difficulty of accurate translation. I *think* I understand what M. Chapeleon is trying to explain, but to put it into words would incur the risk of *mis*interpretation, and after all, why give space to it, when he has made it clear that reinforced compounding has never been the practice in France ; it would only be flogging a dead horse. In all my very numerous runs in France I have never seen it brought into practice. Live steam is merely admitted into the l.p. cylinders at starting, via the receiver, and this is not what has generally been regarded in England as " reinforced compounding."

** This paragraph is not entirely clear to me, nor, I fear, will it be to the reader—neither the translator, one of the Motive Power staff of the C.P.R., Montreal, nor I, has quite fathomed it. Sometimes it proves even more difficult to get the exact meaning of technical than of colloquial French, and the latter on occasion cannot be translated at all.

Fig. 11—" A1 " at the Gare St. Lazare, April 23, 1947. To the right Inspector Deschamp, chief mecanicien and instructor

" I hope, dear Mr. Livesay, that my reply will be according to your wishes ; but I hold myself, of course, at your disposal for all the supplementary clarifications which you may require.

" With my best regards, be assured of my cordial sentiments.

A. CHAPELON."

It will be agreed that, coming from such a source, the foregoing statements are well worthy of attention. In them M. Chapelon underlines the importance of treating the locomotive as a three-part whole—boiler, motor and " disposal factors," exhaust passages, blast-pipe and chimney. All must work well together ; if any one fails in respect to the others, the power output of the whole is adversely affected, and no amount of " tinkering " will remedy things. Particularly is this true of smokebox arrangements, to which greater attention has at long last been paid in Britain by the adoption of Kylchap blast-nozzles and chimneys.

In the first part of this article it was stated that the writer went to France not only to study the engines, but the humanities—that is, the human element—the men running and caring for the machines that were doing such outstanding work, as it was evident only thoroughly well-trained personnel could possibly get the superlative results for which the French locomotives are noted. This all comes out very plainly on the footplate, the competence of French enginemen, and the skill with which they handle their complex machines being a matter of common knowledge, the natural outcome being locomotive performance of the highest order, seemingly often out of proportion to the size of the engines. This is particularly the case with the Chapelon 231-E class, which are " Super-Pacifics " only in power-output, not dimensions (Fig. 1). British " Pacifics," such as " A4s " and " Coronations " are several tons heavier, especially in adhesion, and other features are at least comparable, but considerable experience of both these fine classes does not lead me to conclude they could equal, still less exceed, the performances of the forty-six-year-old Chapelon engines, which still handle 600-ton trains with ease, showing no objection to being " thrashed " when this is necessary ; they are old, but evidently still perfectly efficient. Have we in Britain any engines of that age capable of such work—or of any age ? I very much doubt it. But however effective the French engines may be, it is essential that skilled men handle them on the road, and care for them in the shed and shop if they are to show their full potentialities. It is obvious that such men have always been available on the S.N.C.F., and still are ; the training they receive accounts for much of the success achieved with their engines. The following outline of this training will show how very thorough their instruction is, and that it continues right through their service.

An aspirant for footplate or shop work on the S.N.C.F. must be between fourteen and fifteen years of age ; he enters by means of a competition—not so arbitrary as an examination—by which his intelligence and general knowledge can be assessed, and his acquaintance with French, mathematics and drawing. If this preliminary interrogation is satisfactory, he enters a technical School as an apprentice ; there are five of these schools in the Northern Region, at Ermont, Vitry, Tergnier, Lens and Douai, each able to take care of forty to fifty boarders annually for the first year of their courses. The foregoing applies to entrants for Motive Power careers, other departments having their own schools. As there are generally more applicants for traction work than are required, those with inferior qualifications stand no chance, and are soon weeded out.

During these three years the apprentice studies mathematics and physics, while adding to his general knowledge ; at the same time he gets extensive workshop training in fitting, machine-tool and metal-work, ending up during the last year with locomotive repairs, all available types of engines being dealt with both theoretically and practically. Present circumstances naturally dictate that steam locomotives get less

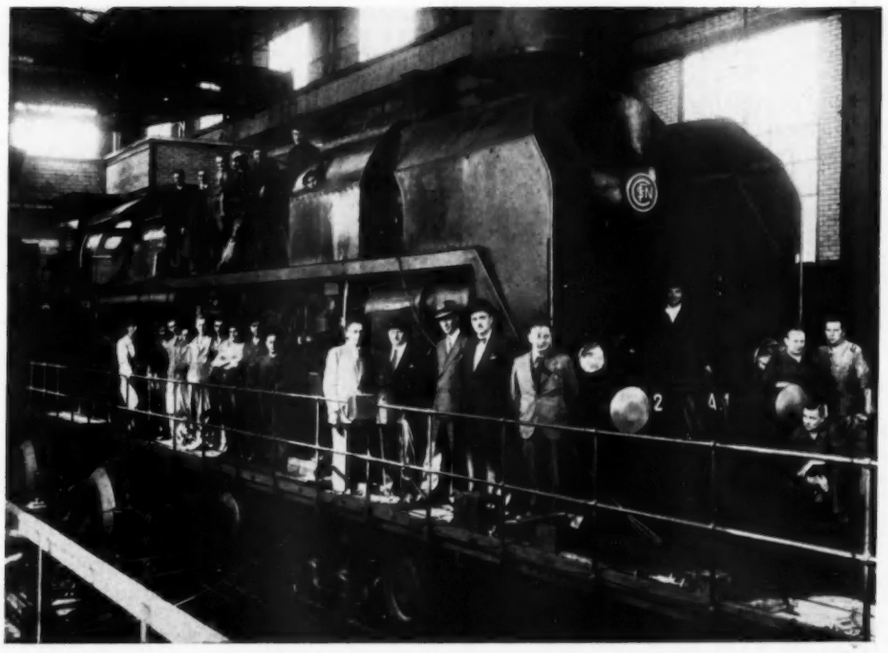


Fig. 12—" A1 " on the Vitry test plant. The tall man in the middle of the central group in front of the cylinder is M. Bohl who was for several years chief of the Vitry plant and on his right is M. Chapelon

and less consideration, diesel and electric more and more ; in particular, yard and branchline diesels come in for considerable attention, in view of their continually increasing number. Nowadays the apprentice has to become *au fait* with all three types of motive power, and must pass an examination at the end of each year ; unsuccessful students are expelled remorselessly should they fail at any one of these tests. He may specialise as fitter, machinist or boiler-maker, but however superior he may be, and irrespective of the particular line he decides to follow, he cannot get to the footplate nor shop before completing his conscriptory service.

Having served his period in the Forces, and if medically fit, the apprentice may choose the footplate if he so wishes, the decision being voluntary ; he becomes successively fireman, pupil-driver, driver, and if his record remains satisfactory he can go farther, by passing a special examination, becoming engine-foreman or inspector. That is to say, he can make either the footplate or shed his sphere, and by specialising in the latter he can become assistant to the shop-foreman or depot-master.

A fireman wishing to become a pupil-driver must pass a very stiff examination covering signals, shunting, safety rules and general railway operation, and must also have a sound basic knowledge of the design, working and maintenance of locomotives, steam, diesel and electric. He remains a pupil-driver for two or three years, handling yard, freight and local passenger engines ; during this period he can act as either driver or fireman as called upon. Finally he becomes a full-fledged mecanicien without any further examination, unless he is to work express or mainline trains, in which case a special and severe examination is compulsory.

Formerly it was the rule that a mecanicien invariably had his own engine, but this is no longer necessarily so ; already it only applies to the Nord Region " Pacifics," and within a couple of years there will only be a few of these left, confined to the Calais and Boulogne Sheds, due to the electrification of the lines to the Belgian frontier. Other types of Nord engines, including the 2–10–0 four-cylinder compound freight machines, mechanically stoked, are now worked by " chain gangs "—in the vernacular—that is, any crew available can be rostered to any of these engines.

Graduates from the Polytechnic Schools with exceptional qualifications do not necessarily have to become enginemen during their upward progress to Shedmaster, Superintendent of Motive Power or District Manager, they gain practical footplate experience for a few months by " standing-by " as an observer, but not driving. Others passing out from the Schools of Arts and Manufactures, or Arts and Trades, have to do six months as fireman, and six to eight months as mecaniciens before being accepted as Shedmaster, Shopforeman, Inspector or Superintendent of Motive Power. On the other hand, the best pupils from the apprentice training schools have to do several years on the footplate before becoming road-foremen of engines and ultimately Inspectors.††

Until recently, a mecanicien was responsible for his own engine until it went into the shops for general repairs—that, is complete overhaul, " Hoisting "—which generally took place after roughly 185,000 miles, and he could work on it as a fitter. Nowadays, with the passing of the steam locomotive, this is no longer necessarily the case, and will soon be very much the exception ; in the end presumably it will cease altogether, as one cannot see the necessity for " one man, one engine " remaining in force when diesels and electrics provide the motive power. An additional reason at the moment is that the number of shops capable of doing major repairs to steam locomotives is becoming progressively smaller ; in fact, there are now only six in all France, and an engine belonging to, say, the Tergnier Depot, Nord Region, may have to go to Rennes, Western Region, or St. Brieux for shopping. The rules governing day to day maintenance, too, are no longer the same ; formerly adjustment and minor repairs were the duty of the mecanicien, and cleanliness that of the fireman, for which he received an additional monthly allowance—all this excellent routine with its beneficial effects on the condition of engines is disappearing, and soon will be but a memory.

Retirement at fifty, this too is likely to go into the discard shortly—and high time it did ! If the present Government succeeds in its latest endeavour the figure will be fifty-five, a far more reasonable age, when a man is still fully capable of handling a locomotive, particularly a diesel or electric, or should be—they require very little handling anyway ! It has long been recognised by the management—though not by the men—that retirement at little more than middle-age is unreasonable, and tentative feelers have been made many times to test the reactions of the men to a possible lengthening of the working period, but to say the least, the reactions were not favourable ! However, at long last, it seems that the extension will take place in the not very distant future ; retirement at fifty is out of harmony with modern social conditions.

On retirement, the French engineman receives a pension roughly equivalent to two-thirds of his pay during the last two years of his service, which seems reasonable, and enough to live on. At any rate it should not be necessary for him to become an outside porter at the Gare du Nord to make ends meet, yet in Britain one finds ex-top-link drivers doing just this at London termini, and I don't think this at all right and proper. I am sure mine is not a " voice crying in the wilderness " in this matter ; many people are with me in protesting.

Rate of pay is hardly a subject one can take up with people one is travelling with on the footplate ; at least I can't, so I made discreet enquiries from officials who were in a position to know the facts. It seems French enginemen were always fairly well paid, but their remuneration has been raised again recently to keep pace with the cost of living—which incidentally is considerably higher than in England. The French equivalent of " top link " drivers get approximately £100 to £120 per month, the amount varying according to mileage, and after adjustment for time-recovery and fuel-saving. But adjustment is also made in the other direction, downwards, for faults of omission and commission ; that is, fines are imposed for due cause. I have not got the equivalent figures for firemen, which naturally vary according to the grade to which they belong, but they are certainly considerably higher than those applying to their British opposite numbers. In a way this is as it should be, as the French fireman has been thoroughly and expensively trained, and the British firemen—well, less so !

Throughout his railway service the French engineman has from time to time periodical health examinations, particular attention being paid to his sight ; others deal with signals, changing rules and regulations, and repair work. He has to attend classes to ensure he is keeping up-to-date with improvements in signal systems, and of course, in engines ; all these are compulsory. Steam enginemen changing over to electric are sent to a special school for at least three months, studying both theory and practice, in order that they may cope with at all events minor derangements. Is it any wonder in the light of all this, that their engines give such fine results, and that breakdowns are so rare ?

As already said, no blame attaches to British Railways for the very different methods adopted in Britain to secure recruits for the lower grades of engine and repair men, and for the sort of men they often have to put up with nowadays—it is their misfortune, not their fault. As an illustration of what B.R. are up against the following story is indicative.

An Inspector with whom I am well acquainted was taking a class of " new entry " firemen, and on one occasion gave me permission to attend, which I did for a couple of hours, and a very good and useful session it proved to be. The Inspector, a good and considerate teacher, failed to get much response ; in fact he got none, nobody asking any questions. Noticing this, and naturally somewhat disappointed, he said : " Now lads, any questions ? Anything you are not quite clear about ? " No returns. " Come along—you've been listening all morning—isn't there anything you want to ask ? " At last one hand went up. " Please, do we get Saturday afternoons off ? " Can one imagine that happening in a French training class ? I cannot—if it did, the culprit would probably be back on the street in quick time—but that British lad very likely is firing an " A4 " at this moment, with more or less success.‡‡

†† MM. Leseigneur and Hugot, who have come so frequently into these articles, were graduates of the Apprentice Training Schools, and M. Fillon, my invaluable courier and interpreter, of the Arts and Trades School.

‡‡ Since the above was written, in a letter from a B.R. Motive Power official who, after reading past articles, went to France several times to find out for himself how things are done over there, making many footplate runs, and so forth, and was greatly impressed, there is found the following : " We have a lot to learn from France, and much of what I have learned I try to apply—but how I envy them. To think that they can afford to give each driver three months for conversion to electrics when we have to put up with three weeks . . . Really one difference—we have so much more to cope with in traffic density." This official, after making many footplate runs in France, on several of the classes of engines I have praised in previous articles, said : " I agree with every word you say about French locomotives." Several times I have expressed regret that British locomotive men have so seldom sought personal experience of French locomotive performance, which, in many respects has led the world—*this* official has done so—and he " agrees with every word I have said about them." *Verb, sap.*!

OBITUARY

WALTER HIGGS

WE regret to record the death of Mr. Walter Higgs, which occurred on August 8. Walter Frank Higgs was born at Kidderminster on April 7, 1886. He was educated at Birmingham Technical School, and then went into the electrical industry, gaining experience with the General Electric Company, the British Thomson-Houston Company, the Electric Construction Company, and others. In 1912 Walter Higgs and his brother founded a small company to manufacture electric motors. This concern he built up from employing a total staff of seven to the present well-known Higgs Motors, Ltd., Witton, Birmingham. He was a member of the Institution of Electrical Engineers and a life governor of Birmingham University. In addition he took a keen interest in both local and national politics, serving on Birmingham City Council from 1934 to 1937, and as a Member of Parliament from 1937 to 1945.

Books just published

Aerofoil Sections, Results from Wind-tunnel Investigations, Theoretical Foundations

281 pages. Illustrations. Diagrams.
Publisher : Butterworths. 1961 *Price 200s.*
by FRIEDRICH WILHELM RIEGELS
Translated from the German by D. G. Randall

Originally published under the title "Aerodynamische Profile" by Verlag R. Oldenbourg, Munich, 1958, this book surveys the subject of wing sections, covering all the main theories and discussing many of the experimental investigations. There is a large amount of tabular and graphical information on the geometrical and aerodynamic characteristics of profiles. Sections are included on nomenclature and geometry, experimental methods, wind-tunnels and corrections, force and moment coefficients, boundary layer control, and the theory of wing sections. There are extensive bibliographies and a subject index.

Copper for Radiant Heating

78 pages. Illustrations. Folding Diagrams.
Publisher : Copper Development Association, 55, South Audley Street, London, W.1. 1961. *Gratis.*

C.D.A. Publication No. 60 deals with the principles of radiant heating using either piped hot water or electric cables. Chapters included are: radiant panel heating ; copper tubes as jointing ; panel design ; heat loss calculations ; circulated hot water systems, panel design and location ; electric floor warming, panel design and location ; and floor and ceiling construction. Tables are given for heat transmittance coefficients for walls and roofs ; rated output of panels ; room temperatures and air change heat losses ; and extracts from the relevant British Standard Specifications.

Health in Industry, a Guide for Engineers, Executives and Doctors

157 pages. Illustrations.
Publisher : Edward Arnold (Publishers), Ltd. 1961. *Price 18s.*
by R. C. BROWNE, M.A., D.M., M.R.C.P.

This is an account of the effect of industrial conditions on workers' health, based on lectures given to students at King's College, Newcastle upon Tyne, where the author is Nuffield Professor of Industrial Health. The contents include chapters on the health of executives, absence due to sickness, equipment design, human aspects of industrial accidents, automation, industrial fatigue, working surroundings, and the effects of chemical substances in the environment of the worker. There is an index and also appendices on the proportion of vanadium in the oil and ash of world oils, the maximum allowable concentrations of gas and vapours, and the addresses of occupational hygiene laboratories.

Influence Surfaces of Orthogonal Anisotropic Plates

225 pages. Diagrams.
Publisher : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. 1961. *Price DM.67.50*
by SIEGFRIED KRUG and PETER STEIN
English translation by Heinz Juhl.

The text and captions are printed in both English and German, the English translation reading rather strangely sometimes. The theoretical basis used was published by Dr. Peter Stein in 1959 under the title "Die Anwendung der Singularitätenmethode zur Berechnung orthogonal anisotroper Platten" edited by Stahlbau-Verlag. Additional theoretical research was reported in the doctorate thesis of Siegfried Krug, Berlin Technical University, 1960. There are twenty-eight pages of text and bibliography, the remainder of the book consisting of diagrammatic examples of surface influences.

Theory of Elasticity

Publisher : Pergamon Press. 1961. *Price 80s.*
by V. V. NOVOZHILOV, M.R.I.N.A.
Translated by J. K. Lusher, B.Sc.(Eng.).

This is a translation of *Teoriya Uprogosti*, Leningrad, Sudpromgiz, 1958. It is a photolitho reproduction of non-letterpress text. The book is intended for students and engineers specialising in structural analysis and is an attempt to familiarise them with the non-linear approach to stress analysis. There are chapters on the theory of deformations, equilibrium, strain energy and related principles. There is a chapter on the use and application of curvilinear co-ordinates and several chapters dealing with the classical (linear) theory of elasticity. A table of basic definitions is given and there is a long, wide-ranging bibliography. There is no index.

Festigkeitsberechnung von Bauelementen des Dampfkessel-, Behalter- und Rohrleitungsbaues

127 pages. Diagrams.
Publisher : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. 1961. *Price DM.32.50*
by SIEGFRIED SCHWAIGERER

German design rules and regulations for steam boilers and pressure vessels (Dampfkessel-Bestimmungen, Technische Vorschriften für Dampfkesselanlagen, Teil "Berechnung," AD-Merkblätter "Berechnung von Druckbehältern." Obtainable from : Carl Heymenns Verlag KG., Cologne 1, Gereonstrasse 18-32, or Beuth-Vertrieb GmbH, Cologne, Friesenplatz 16.) intentionally confine themselves to a mere statement of the recommended design formulae. "Strength Calculations for Structural Elements of Steam Boilers, Pressure Vessels and Pipework" succinctly elucidates the underlying theory and research, with particular reference to the work of Prof. Siebel which during two decades has exerted much influence upon German developments.

Stress Concentration around Holes

Publisher : Pergamon Press. 1961. *Price 84s.*
by G. N. SAVIN.
Translated by E. Gros for the Department of Scientific and Industrial Research. Translation Editor, W. Johnson.

This is a translation of *Kontsentratsiya napryazhenii okolo otverstii* (Moscow/Leningrad, Gostekhteoretizdat, 1951) which has been stated to be one of the most important books on elasticity which has appeared in the last decade. It deals with the problem of stresses set up around holes of various shapes in beams and plates subject to different kinds of loading. The book is based on the work of the author and his students, and there is a concluding chapter comparing experimental data with theoretically obtained results. There is a long bibliography of predominantly Russian source material. The book is non-letterpress reproduced by photolithography and there is no index.

Steel Frame Design Examples

215 pages. Diagrams.
Publisher : Cleaver-Hume Press, Ltd. 1961. *Price 30s.*
by IAN ROBB

The author is Senior Lecturer in Structural Engineering at the Royal Technical College, Salford, and the book is intended for the intermediate student in structural design. The subject is treated from a practical standpoint using the latest Codes of Practice. There is a chapter of exercises and a brief subject index. General aspects are treated first, specifications, order of procedure, choice of sections, cost factor, &c. Then follow examples of design of a multi-storey shop premises, a 60ft span shed with ridge-type roof trusses, a large span industrial building with lattice girders, and a braced tower supporting a water tank.

Vibration Mills and Vibration Milling

Publisher : Constable and Co. Ltd. 1961. *Price 25s.*
by H. E. ROSE, D.Sc.(Eng.), Ph.D., A.C.G.I., M.I.Mech.E., M.I.C.E. and R. M. E. SULLIVAN, Ph.D., B.Sc.(Eng.).

This is the fourth in a series of volumes written by Drs. Rose and Sullivan of the Powder Science Laboratory of King's College, London, and is largely based upon the results of experimental investigations carried out at that laboratory together with material made available by mill manufacturers. It is stated to be the only available book on the subject and should be of value to research workers and students faced with the analysis of the statistical behaviour of particulate matter in the presence of many variable factors. The authors suggest new designs of mill and show how best to obtain maximum efficiency in grinding. There are chapters on grinding rate, power requirements, efficiency, and design considerations. There is an index.

Steels for Reactor Pressure Circuits

Publisher : The Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1. 1961.
Illustrations. Diagrams. Price 65s.
Report of a symposium held in London, November 30 to December 2, 1960, by the Iron and Steel Institute for the British Nuclear Energy Conference.

After an introductory address by Sir Leonard Owen on steel and nuclear power, the book consists of articles by some thirty contributors on different problems and aspects of the use of steel in nuclear engineering. There are seven papers on the high-temperature properties of steel, referring to creep, graphitisation, decomposition and stress relaxation. There are three papers on corrosion and three on fabrication questions. Eight papers were given on irradiation effects, and the concluding session consisted of four papers on the improvement of steels. There is a bibliography attached to many of the printed papers together with notes on the discussions. There is no index.

Design and Construction of Foundations

Publisher : Concrete Publications, Ltd., 14, Dartmouth Street., London, S.W.1. 1961.
Diagrams. Price 25s.
by G. P. MANNING, M.Eng., M.Inst.C.E.

The book is intended for everyday use and is restricted to work that would normally be undertaken by a civil engineer in general practice. There is a brief general survey of submerged sites but it is otherwise restricted to land sites. The contents include site investigation, constructional operations and materials. There are chapters on different types of concrete founcations and on mass concrete piers and walls. Piles, caissons on land sites, anchor bases, and foundations subject to lateral loads are also dealt with. There is a brief subject index and two appendices on the bending resistance of rectangular members and the column strength of long piles.

Current Trends in Scientific Research

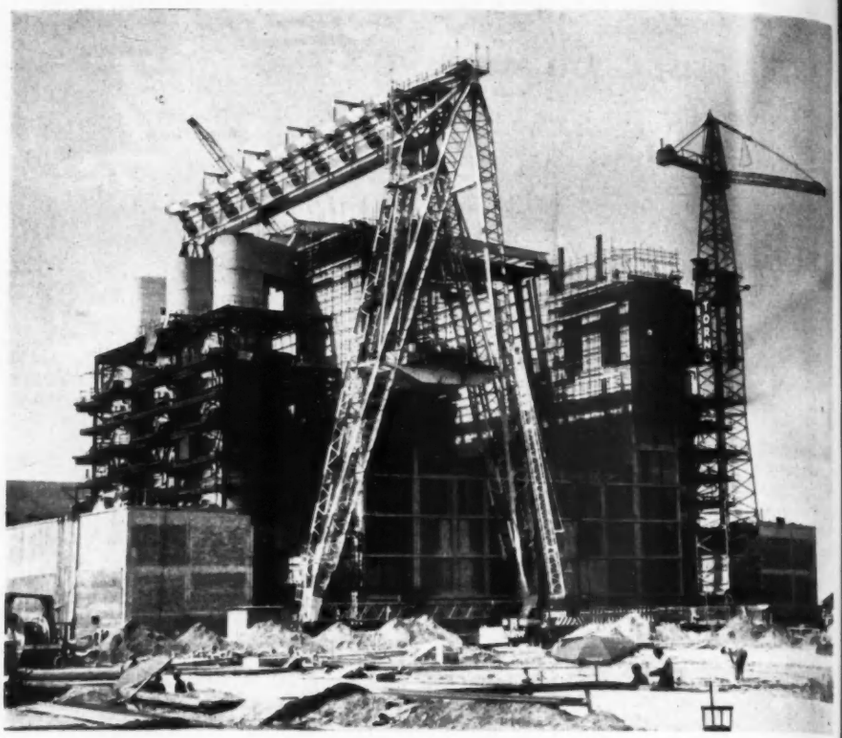
Publisher : H.M.S.O. for U.N.E.S.C.O. 1961.
245 pages. Price 33s.
by PIERRE AUGER.

This book is the result of a resolution passed by the General Assembly of the United Nations on November 14, 1958, the substance of which is contained in the sub-title of the book "survey of the main trends of inquiry in the field of the natural sciences, the dissemination of scientific knowledge, and the application of such knowledge for peaceful ends." The author selected for this Herculean task is a French physicist and former head of U.N.E.S.C.O.'s Natural Science Department. There is an introduction on the development of scientific research; part one consists of the trends of scientific research, in the different sciences, part two is on the organisation of research and the dissemination of results, and part three consists of general and special recommendations.

Latina Nuclear Power Station

The photographs reproduced here give some indication of the progress made with the building of the 200MW Latina " B " nuclear power station, near Rome. Work was started on the site in October, 1958, and the station, now in an advanced stage of construction, is due to be operating next year.

Latina, Italy's first nuclear power station, incorporates a single gas-cooled graphite-moderated reactor with natural uranium fuel. Steam is generated in six boilers and supplied to three 70MW main turbo-alternators. The station is designed by The Nuclear Power Plant Company, Ltd. (which is now a partner company of The Nuclear Power Group), and is being built in association with A.G.I.P. Nucleare of Milan. When the station is commissioned it will be operated by S.I.M.E.A. (Societa Italiana Meridionale per L'Energia Atomica).

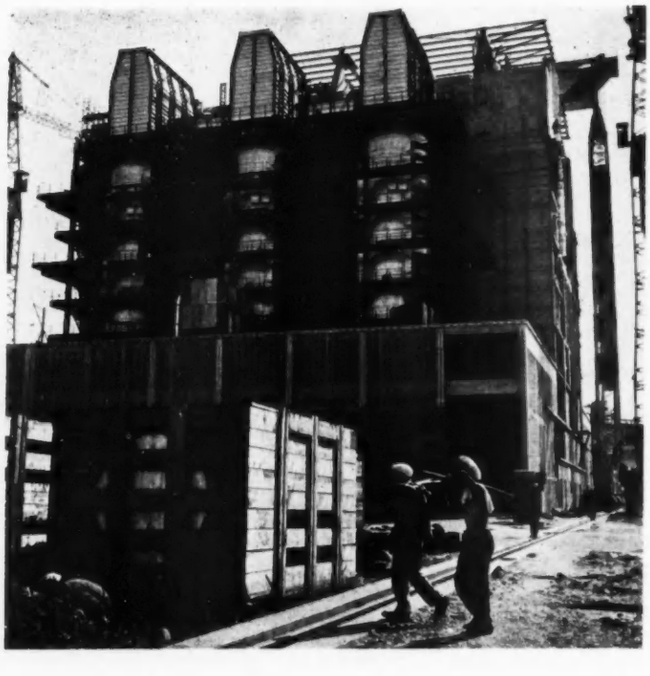


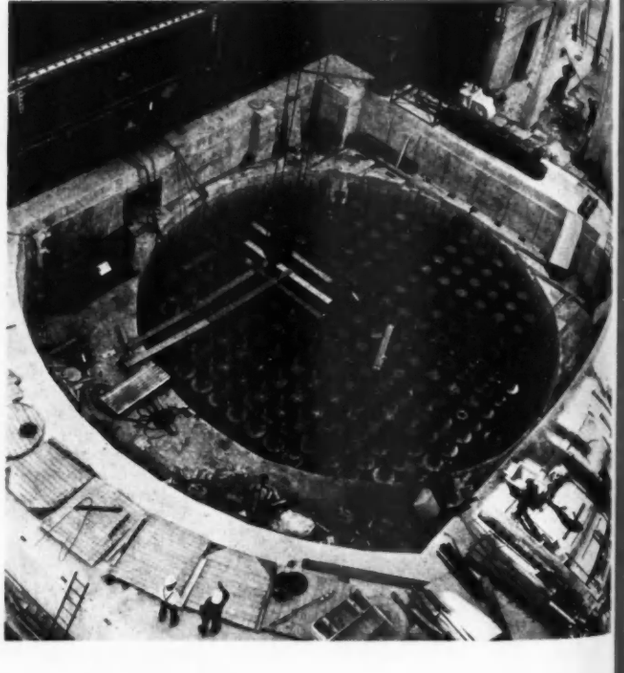
Briefly the present position on site is as follows. In the reactor building (ABOVE and BELOW, LEFT) the spherical pressure vessel has been practically completed. It has been pressure-tested hydraulically and then stress relieved. Inside the pressure vessel the toroidal gas baffle has been installed and so has the structural grid which will carry the graphite core. After the inside surface of the vessel has been cleaned the next major operation will be that of laying the graphite. At the top of the vessel all the standpipes for the fuel element loading and discharging, control rods, &c., have been fitted and tested. A view of the reactor pile cap, showing the standpipes and muffs, is given (BELOW, RIGHT). The gantry for the charge/discharge machine has been erected.

All the six boilers are in position. Four of them are fully tubed and this work is in hand on the other two. In the view ABOVE, three of the completed boilers and their protected carbon-dioxide ducts can be seen. The other view BELOW, LEFT shows three of the boilers, each with a temporary " clean conditions " enclosure on top of it. Of the six gas circulators one is complete and four others, in various stages are being erected on site.

The turbine house is structurally complete except for external finishing work. Two of the main 70MW turbo-alternators are being erected and the condensers for all three sets have been installed. There will also be two 9·5MW auxiliary turbo-alternators for the electrical supplies to the motors driving the gas circulators. Both the condensers for these sets have been installed and one of the auxiliary sets is completed. In the diesel engine house the three sets required for standby duty, to supply the essential services in an emergency, have been installed and are being tested. The first control panels are now being installed in the main control room.

Cooling water for the turbine condensers is taken from the sea by open inlet and outlet culverts which are linked with the c.w. intake by a pier. The outlet culvert has been completed and work on the inlet culvert is well advanced. The two main c.w. pumps have been installed in the " open " pump house which is near the landward end of the inlet culvert. Civil engineering work in connection with the cooling pond is up to schedule.





Precise Measurement of the Straightness of Cylindrical Surfaces*

By R. G. N. HALL, A.M.I.Mech.E., A.M.I.Prod.E.

This article describes an interferometric method, using simply constructed equipment, by which the straightness of a generator of a cylindrical surface up to 12in in length may be measured, without damage, to an accuracy of ±5 microinches even when the total error may be as much as 100 microinches. A simple method of pen recording is described which enables the magnitude and sign of the errors to be deduced directly.

FOR a number of years the National Physical Laboratory has been concerned with the production of diffraction gratings derived from very fine helices ruled on accurately finished metal cylinders.[1,2,3]

The metal cylinders or mandrels, which may be up to 12in long and 2in diameter, are usually of brass and need to be polished and figured to optical standards. It is essential throughout the polishing process that any errors of the straightness of their generators are known to an accuracy of ±20 microinches. In order to evaluate the figure of these cylinders, an interferometric technique has been developed which is capable of measuring the straightness of a generator to an accuracy of ±5 microinches.

By using this technique actual contact with the metal surface during measurement is unnecessary, thus permitting soft metals to be examined without damage.

It is well known that when interference occurs between light reflected from two slightly inclined truly plane surfaces, as in a Fiseau interferometer, a series of fringes can be observed. These fringes are straight, parallel and equidistant. If either surface is curved the fringes are also curved, and the error of the surface is deduced by measuring the departure of a fringe from a straight line joining its ends in terms of the mean fringe separation. If, however, one of the surfaces is a cylinder with its axis parallel to the reference flat, fringes will be observed parallel to the cylinder generator. Such fringes are no longer equidistant, but their spacing follows a quadratic law, becoming closer together the greater the distance from the generator nearest the flat. The straightness of a generator is indicated, therefore, by the straightness of the fringes that lie either side of the generator nearest the flat, but the evaluation of the error of a generator to a precision of 1 microinch requires a measurement of the spatial fringe separation to an accuracy of a few ten thousandths of an inch for a 1in diameter cylinder.[4]

If, however, a small inclination is introduced between the cylinder and the reference flat the fringes on either side of the generator then converge to meet at a series of points along it. The pattern of the fringes is now similar to a series of arrow-heads with their tips lying along the generator. Such fringes will occur at positions where the separation between the two surfaces has altered precisely one-half wavelength of the illuminating light and whereas for a true generator the tips will be equally spaced, any curvature present will be denoted by irregular spacings of these fringes.

Monochromatic light of a wavelength of approximately 21·6 microinches (the green line of a mercury source) has been used for this work. It is therefore possible, by selecting an appropriate angle between the flat and cylinder, to produce a fringe frequency along the generator whereby a knowledge of the fringe positions to an accuracy of 0·015in is equivalent to a generator error of 1 microinch.

Description of Apparatus

The measuring equipment is shown diagrammatically in Fig. 1 and with the exception of the optical flat accurate machining and fitting is not required.

The cylinder *A* to be measured is held by male centres attached to the main base of the equipment. The reference flat *B*, bismuth oxide coated to improve fringe contrast, is supported in a near vertical position, but leans towards the cylinder. This near vertical arrangement of the reference flat eliminates distortions which might arise if it were mounted horizontally. The wedge angle between flat and cylinder is controlled by two thin wire spacers D_1 and D_2, of slightly different diameters, situated near the extreme ends of the cylinder, but affixed to the flat.

The fringes are viewed by a ×40 microscope *H* mounted on a carriage running on slideways parallel to the mandrel being examined. A miniature mercury vapour lamp (Siemens N.2) *C* is mounted well above the carriage. In order to obtain monochromatic light from the lamp, a Wratten 77A filter is placed on the aperture platform *E*. Collimation of the light is effected by the lens *F* and the resulting parallel light is reflected by the beam-splitter *G* to strike the optical flat at normal incidence.

The carriage carrying the microscope, beam-splitter, &c., is kinematically supported by two vees sliding on the cylindrical rod *K* and by a hemisphere, sliding on the flat *J*, immediately below the generator being examined. The vees are spaced at a distance apart of 12in ; the measuring scale, against which the positions of the fringes are determined, is about 4in from the surface being examined. Since it is only necessary to measure the position of any fringe, if the number of fringes per inch is approximately 7, to an accuracy of 0·015in in order to achieve an accuracy of 1 microinch, the straightness of the guideways is relatively unimportant, e.g. a local error of 0·045in in straightness of the guide rod *K* will only introduce an error of approximately 1 microinch in the determination of the straightness of the generator being examined.

The position of the microscope carriage can be recorded by marking a paper tape with the pen *I*. If required the tape and pen may be replaced by a simple scale and cursor.

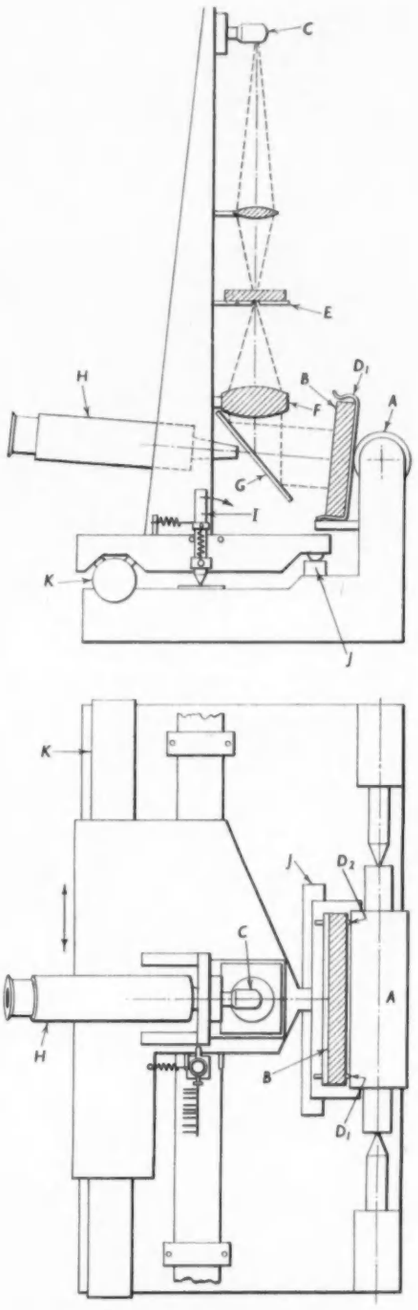


Fig. 1—Diagram of apparatus

Observational Procedure

The number of fringes observed along the length of a generator in the interferometer will be dependent on the wavelength of the light source and the difference in diameter of the wire spacers D_1 and D_2 (Fig. 1).

Hence

$$\text{Number of fringes/inch} = \frac{2(D_1 - D_2)}{\lambda L}$$

where

L = Distance between wire spacers (inches).

D_1 and D_2 = Wire spacer diameter (inches).

λ = Source wavelength (inches)

Wires of 0·0014in and 0·001in diameter will give a frequency of 6 to 7 fringes per inch at a separation of 6in or about three

* Communication from the National Physical Laboratory.

per inch at a separation of 12in and both these conditions have been found to be satisfactory in practice.

The fringes appear in the viewing microscope as sharp arrow heads (Fig. 2(*a*)—(*d*)). The criterion chosen for setting is for the cross-wire of the microscope to be at the centre of gravity of the fringe, i.e. at a point mid-way between the tip of the arrow and the position where the fringe separates, Fig. 2(*d*) and Fig. 3. The distance between tip and point of separation is usually about 0·030in for a fringe frequency of about seven per inch. When the first fringe has been located the position of the slide carrying the microscope is recorded. The carriage is then moved until the next fringe occupies a similar position relative to the microscope cross-wires, its position is again recorded, and this procedure is repeated for every subsequent fringe.

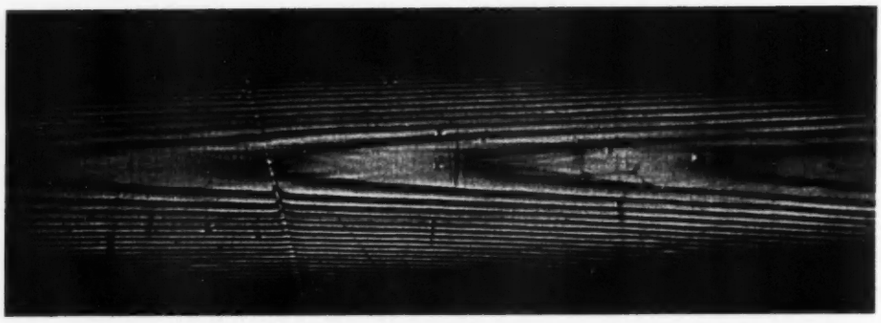


Fig. 2 (*a*)—Fringe system produced by polished speculum-plated cylinder (approximately seventeen fringes per inch)

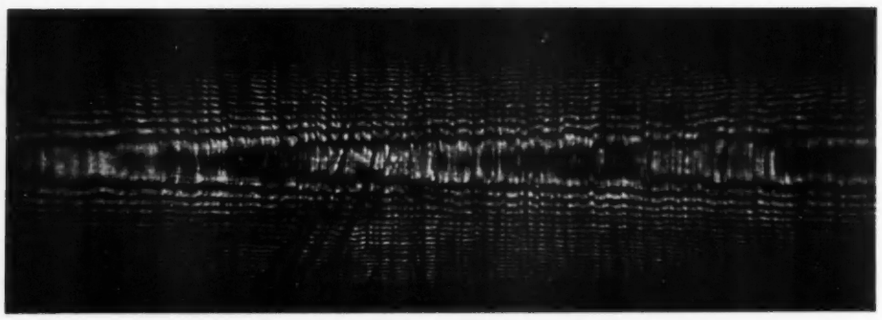


Fig. 2 (*b*)—Fringe system produced by a precision ground brass cylinder (approximately twelve fringes per inch)

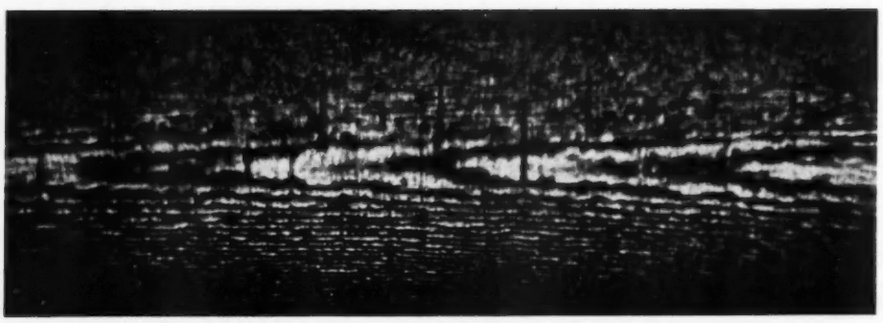


Fig. 2 (*c*)—Fringe system produced by a part-polished brass cylinder (approximately twelve fringes per inch)

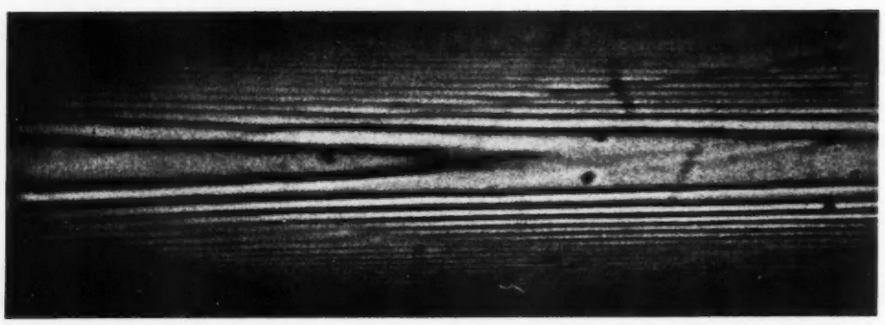


Fig. 2 (*d*)—Configuration of fringe from polished surface. Wedge angle adjusted to give approximately seven fringes per inch

Determination of Errors

Where scale readings of fringe positions have been taken it is first necessary to determine the mean fringe frequency (F_f) by dividing the total number of fringes (counting the first as zero) by the distance between the first and last.

The departure of the generator from a straight line, in fringes, will then be the difference between the integral number of fringes observed at any point and the calculated fringe number based on the mean fringe frequency. Thus the error at the n^{th} fringe position is given by;

Generator error

$$(G_e)=[(F_f \times S)-n] \text{ fringes}$$

where

F_f = Number of fringes/inch (calculated)

S = Distance between first and n^{th} fringe

n = Number of fringes (observed)

Provided measurements are made from the small to the large wire diameter, a negative value of the generator error indicates a concave surface and a positive value a convex. Table I shows a typical example for a generator concave by approximately 68 microinches, i.e a "waisted" cylinder.

Table I—*Generator Errors Derived from Scale Readings*

Fringe No. (observed)	Fringe position (in)	Fringe No. (calculated)	Generator error (fringes)	Generator error (microinches)
n	S	$Ff \times S$	$[(F_f \times S) - n]$ G_e	$G_e \times 10^{-8}$
0	0	0	0	0
1	0·06	0·42	−0·58	−6·26
2	0·16	1·13	−0·87	−9·40
3	0·20	1·41	−1·59	−17·17
4	0·30	2·11	−1·89	−20·41
5	0·39	2·74	−2·26	−24·41
6	0·48	3·38	−2·62	−28·30
7	0·58	4·08	−2·92	−31·54
8	0·69	4·85	−3·15	−34·02
9	0·80	5·63	−3·37	−36·40
10	0·90	6·33	−3·67	−39·64
11	1·00	7·03	−3·97	−42·88
12	1·10	7·74	−4·26	−46·01
13	1·24	8·72	−4·28	−46·22
14	1·36	9·56	−4·44	−47·95
15	1·46	10·27	−4·73	−51·08
16	1·59	11·18	−4·82	−52·06
17	1·70	11·96	−5·04	−54·43
18	1·82	12·80	−5·20	−56·16
19	1·94	13·64	−5·36	−57·89
20	2·06	14·49	−5·51	−59·51
21	2·18	15·33	−5·67	−61·24
22	2·29	16·11	−5·89	−63·61
23	2·42	17·02	−5·98	−64·58
24	2·56	18·00	−6·00	−64·80
25	2·66	18·71	−6·29	−67·93
26	2·81	19·76	−6·24	−67·39
27	2·96	20·82	−6·18	−66·74
28	3·12	21·94	−6·06	−65·45
29	3·26	22·93	−6·07	−65·56
30	3·39	23·84	−6·16	−66·53
31	3·52	24·76	−6·24	−67·39
32	3·69	25·95	−6·05	−65·34
33	3·88	27·29	−5·71	−61·67
34	4·08	28·69	−5·31	−57·35
35	4·26	29·96	−5·04	−54·43
36	4·42	31·09	−4·91	−53·03
37	4·62	32·49	−4·51	−48·71
38	4·87	34·25	−3·75	−40·50
39	5·13	36·08	−2·92	−31·54
40	5·45	38·33	−1·67	−18·04
41	5·83	41·00	0	0

Fringe Frequency $F_f = \frac{41}{5 \cdot 83} = 7 \cdot 033$

For most work calculation is unnecessary and a graphical solution may be derived from the paper tape. Using this technique it is only necessary to set the microscope to a fringe position and depress the marker pen. Not only are the possibilities of error of reading the position minimised, but measurements may be made without disturbing the observer's adaptation. This is very convenient especially under conditions of poor fringe contrast.

The paper tape derived is used as a scale

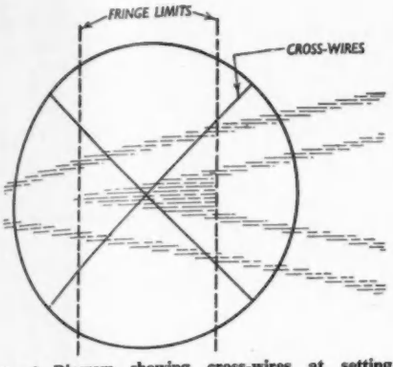


Fig. 3—Diagram showing cross-wires at setting position on fringe

to construct the graph illustrated in Fig. 4(*a*). The ordinates relative to a straight line drawn between the end fringe positions, are the errors of the generator and can be conveniently replotted in the form shown in Fig. 4(*b*).

Provided the measurements are made from the small to the large wire diameter and the plotting origin is top left, errors below the straight line indicate concavity or minus metal, and errors above convexity or excess metal.

Accuracy of Determination

The limitation of accuracy of this equipment is imposed by the micro-structure of the surface being measured. The apparatus has been mainly used to test the straightness of brass cylinders and although the finish of the brass, when polishing is complete, is highly specular, irregularities on a microscale are often present which are sufficient to impair the fringe quality and hence influence the fiducial setting of the microscope. The greatest discrepancies in fringe setting occur when measurements are taken during the intermediate stages of polishing. Here, lack of repetition of the order of ± 3 microinches has been found to exist between sets of readings for the same generator. The reasons for diagreement of this magnitude will be apparent if the fringe configurations illustrated in Fig. 2(*b*) and 2(*c*) are studied.

Another source of error is of course the accuracy with which the position of the microscope carriage can be determined, but it is quite easy to read the paper tape or scale to an accuracy of $\pm 0{\cdot}010$in and this for a normal fringe frequency is equivalent to an error in the generator curve of less than 1 microinch. The errors of the reference flat must of course be known and if necessary these corrections can be easily applied to the error curve derived for the cylinder. Calibration of the flat can be made to an accuracy of $\pm$ 1microinch and it may be mentioned that it is only necessary to calibrate the line of the flat against which the comparison with the cylinder is to be made.

Conclusions

The accuracy of the method depends greatly, as has been mentioned, on the quality of the surface being measured. However, it is considered that the overall accuracy when applied to brass specimens in the early stages of polishing is of the order of ± 5 microinches and that as the quality of the surface improves this error reduced to probably ± 3 microinches. Higher accuracies can undoubtedly be obtained on surfaces possessing finer micro-structures.

The technique described has been developed specifically for measuring mandrels for diffraction grating manufacture. Provided a suitable reference flat is available there does not appear to be any limit to size. The system as used is not particularly susceptible to vibration and may, therefore, be installed in or near a workshop, provided suitable temperature controlled conditions exist.

Acknowledgments

The author wishes to acknowledge the contributions made to the experimental work by Mrs. P. J. McCormick. The work described above has been carried out as part of the research programme of the National Physical Laboratory and this paper is published by permission of the director of the Laboratory.

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[2] Dow, G. D., *Journal Sci. Instrum.*, 1956, 33, 348.
[3] Stanley, V. W., and Hall, R. G. N., *Prod. Engineer*, 1961 Vol. 40, No. 1, page 38.
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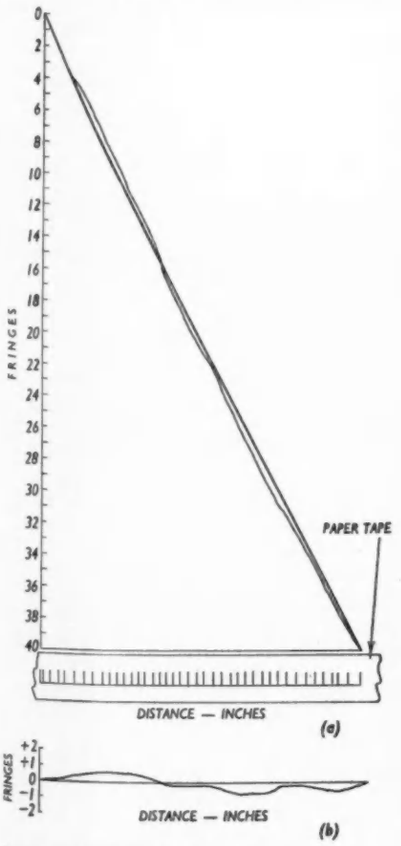


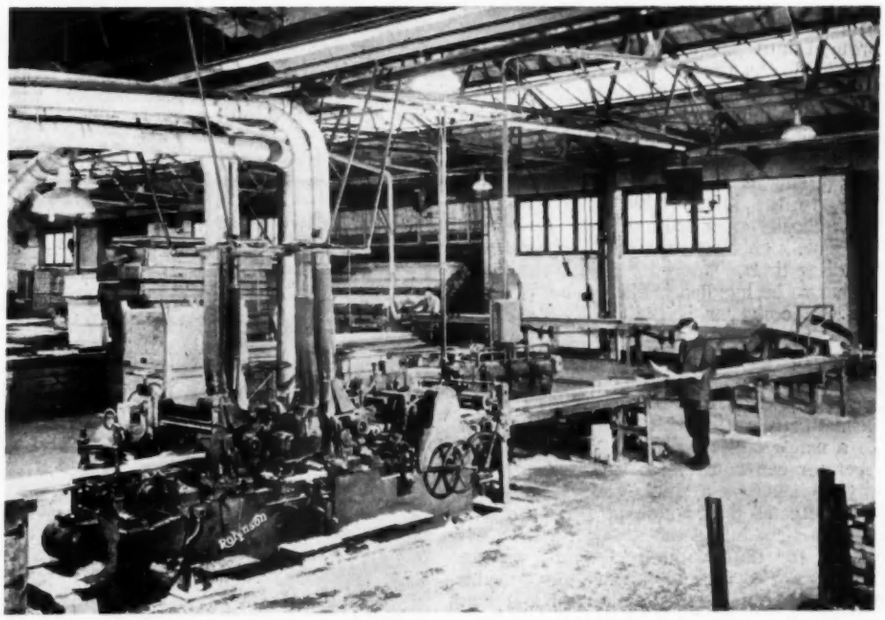
Fig. 4 (*a*)—Fringe positions plotted from paper tape
Fig. 4 (*b*)—Plot of generator errors obtained from (*a*)

Automatic Transfer Line for Sawmill

Advantage has been taken of modern mechanical handling and transfer equipment in the development of an automatic sawmill plant incorporating a yard bogie, cross-cut saw and moulder by Thomas Robinson and Son, Ltd., of Rochdale, in co-operation with R. H. Buckley, of Newhey, Rochdale. This line receives random-length unplaned timbers and from them produces moulded stock under the control of a single operator.

About eighteen months ago there was installed in the works of a joinery mill engaged in mass production an automatic transfer and machine line for the manufacture of moulded stock. This equipment was developed and installed by Thomas Robinson and Son, Ltd., and R. H. Buckley, of Rochdale, and a second line has just been supplied to the same works. These two installations, each controlled by a single man, have an output equivalent to six three-man-teamed conventional cross-cut saws feeding two moulders.

The line (illustrated below, as seen from the outfeed end) starts at the specially developed tilting travelling unloader hoist,



Moulding machine and conveyor line from outfeed end. The cross-cut saw and tilt-hoist can be seen in the background

Truck delivering timber sett to tilt hoist

shown above, to which a truck delivers a standard timber sett from the yard. This hoist can also be adapted to take the timber from a stillage or floor chassis in the yard, and traverse into the mill. The timber rests in the take-off arms of the hoist, which are then tilted over to deliver it layer by layer on to a side delivery conveyor, as illustrated below. The two take-off arms normally provided on the hoist are braced to form a rigid frame and for long lengths or thin boards three or more arms can be provided. The hoist and tilt mechanism is operated, through a reduction gearbox, by a motor fitted with a magnetic brake, the arms rising in stages to discharge each layer over the masts. Limit switches which govern the extreme rise and fall of arms and the horizontal movement of hoist allow the operator from a seated position at the cross-cut saw to reset the hoist quickly and positively.

After taking the load from a timber truck, the hoist moves well clear before discharging so that another truck can be immediately brought into position in readiness for the next load. As a result, minimum time is lost when recharging the hoist; in fact, only a little over half a minute elapses between receiving the truck to recommencing production.

The side delivery conveyor spaces the timber lengths and delivers them, one at a time, to the infeed table of a Robinson hydraulically operated, straight-line cross-cut saw. This conveyor is "decked" for handling timber stacked "solid," but if the timber to be handled is likely to be "in stick" the side conveyor is built with a skeleton framing. This skeleton framing allows the sticks to be separated from the timber lengths by dropping between the side conveyor chains on to a belt conveyor running beneath and on this belt they are transferred to a single collection point. The cross-cut operator can control the side delivery conveyor chains by a single hand lever which also actuates linked side pressure arms on the cross-cut infeed table. The infeed table rollers for the handling of timber in the length are driven by heavy-duty chains enclosed within the side channels and they can be driven in either direction.

The hand lever operates linked side pressure arms on the cross-cut infeed roller table control the lengths whilst they are being conveyed, and hold them against the fence during the cut. When the hand-lever is actuated to open the arms fully to receive the next length, a switch is automatically closed to start the side delivery chains in motion. These chains run until, immediately after the next length has been dropped into position, the hand lever is then actuated to push the length against the cross-cut fence.

Heavy-duty conveyor belts on the outfeed side of the cross-cut saw handle the cut pieces, and up to sixteen adjustable stops are provided for length gauging, their distance from the saw cut being set from a graduated rule on a hexagonal gauge bar on which they are mounted. The stops are brought into use in sequence, and retracted, by one of two hand levers fitted side by side at the front of the machine. Each lever controls up to eight stops and has a coloured plastic knob to identify it with its own bank of stops. Each lever moves in a numbered quadrant placed at the front of the machine and within easy reach of the operator. Any stop can be selected, as required, and will remain operative until reset.

The stops can be set to gauge up to 16ft, and to prevent overshooting the required stop on the longer lengths, a pair of additional gate arms are provided mid-way along the outfeed table. These arms are preset to close in to the width of pieces being handled, thus forming a gate through which they must pass, and in doing so strike the required stop.

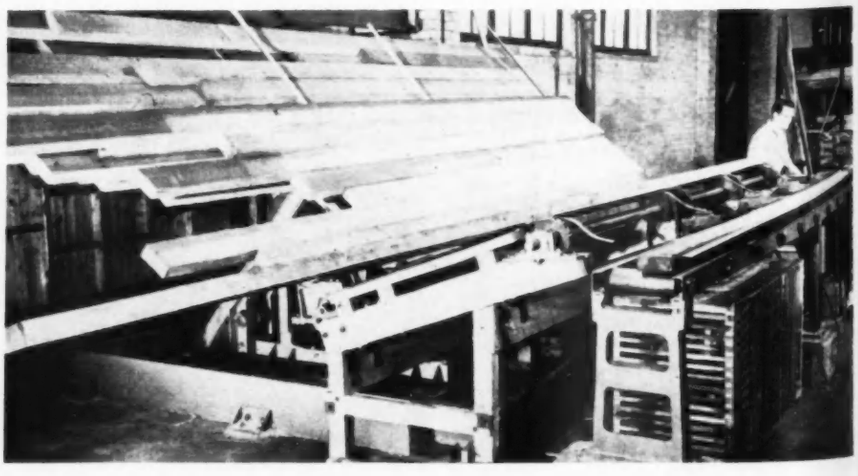
In addition to the length-gauging stops, a trim stop can be provided for squaring-off the ends of the timber. This stop is operated by pull-rod and is spring-loaded to drop clear after the cut is set. Trimmings automatically drop through the tables into a waste box at the side of the machine, or on to a waste conveyor belt.

As the saw completes its cutting stroke, hydraulically operated kickers automatically push the cut piece clear of the stop tongue so that it is free to move along the outfeed conveyor belt. These kickers retract immediately enabling the timber to move into position for the next cut without loss of time, and kickers can be quickly adjusted along the hexagonal bar to the most effective position between the stops.

From cross-cut outfeed table the cut pieces are fed into a moulder by belt conveyors, each consisting of one, two or three sections arranged in line and provided with the necessary fence, guides and individual motor drive.

Immediately in front of the moulder supplementary nipping rollers act in conjunction with the conveyors to force the entry of the pieces into the machine's feed rollers. To ensure constant supply of end-butted pieces, this final conveyor section operates at a feed rate approximately 50 per cent above that of the moulder. To provide for variations in the moulder feed speed, cone drive pulleys are incorporated in the self-contained drive to the conveyor and nipping rollers. The length of the feed conveyors and their speeds are such that a number of pieces can accumulate on the conveyor section leading to the moulder to ensure that the machine is fed continuously even though the cross-cutting operation is intermittent.

The makers point out that the conveyors can be arranged to feed round a bend, as can be seen in one of our illustrations, or in a straight line into the moulder. Alternatively, when the cross-cut saw is required to feed more than one machine, a second route, together with the necessary selector gates, &c., can be provided. Escape points and reserve storage can also be arranged, so that the production of one machine is not held up by the



Timber sett on tilt hoist being discharged on to cross-cut saw infeed table via side conveyor

temporary stoppage of the preceding or following machine. If for any reason the cross-cut saw is operating alone, i.e. without the moulder, cut pieces can be taken off and stillaged anywhere along the conveyor route and subsequently fed back on to the conveyor without the stillages having to be moved.

The controls for the cross-cut saw, length-gauging stops, conveyors and tilting hoist are conveniently grouped at the front of the cross-cut saw within easy reach of the operator. From this station the operator is able to control the unloading of the timber truck, delivery of lengths to cross-cut saw, where he can inspect and cut to selected lengths, ultimately feeding cut pieces into the moulder via the conveyor system.

These two transfer lines, claimed to be the first of their kind to be designed, installed and in production, indicate future trends in timber processing layout for continuous-flow production. The equipment described is, we are informed, but a part of the programme being currently undertaken jointly by the two firms which are now offering to supply equipment for feeding and "taking off" from high-speed moulders, resaws, bandmills, &c., with a design service extending, where necessary, to complete sawing and planing mills, joinery works, and other factories.

Letters to the Editor

TYPE-5 DIESEL ELECTRIC LOCOMOTIVES

SIR,—I notice on page 155 of the issue of July 28, 1961, under the heading "Type-5 Diesel Electric Locomotives" it is stated that as a result of fitting shorter bogies with a wheel base of 13ft 6in instead of 14ft 4in, this change has increased the availability of the "Deltic" class, enabling it to operate over lines from which the prototype was barred because its longer bogies infringed certain platform clearances. The shortening of a bogie wheel base will not necessarily improve route availability because it increases bridge unit loads. If additionally the bogie centres are increased in length, as in the case of the "Deltic," this will for another reason, namely increased throw over at the centre, make route availability worse, not better. The fact that the route availability of the present "Deltic" is better than was the case with the prototype is entirely due to the body profile at the centre of the body being redesigned to conform to the loading gauge at the maximum throw over point.

J. F. HARRISON

Chief Mechanical Engineer
British Transport Commission,
London, N.W.1.
August 8, 1961.

APPEAL BY A MUSEUM

SIR,—In the Borough of Eccles there has been opened recently a museum and art gallery at Monks Hall, where we are anxious to assemble as many specimens as possible of the products of local manufacturers and examples of local industrial development. We are particularly anxious to obtain—for temporary exhibition or permanent safe custody—items illustrative of the major local developments in the technical sphere. Among these connections are the following :

James Nasmyth : We should very much like to obtain an early steam-hammer as this outstandingly successful machine tool was initially the main cause of this town's expansion in the nineteenth century, and indeed figures in the Borough coat of arms.

A. V. Roe : This pioneer in aviation was born in Eccles.

The Bridgewater Canal : The canal passes through the centre of Eccles, from north to south, and is another cause of local growth and prosperity : an exhibition to celebrate its Bicentenary is to be held at Monks Hall in September, 1961.

The Liverpool–Manchester Railway, which bisects the town from east to west.

The Manchester Ship Canal, the borough's southern boundary.

The Binks Carburettor, which was formerly made in Eccles.

It will be greatly appreciated if any of your readers who are able to help will get into touch with me.

J. F. W. BRYON
Borough Librarian and Curator,
Eccles Public Libraries

Eccles.
August 11, 1961.

PRECISE CONTROL OF 3000-TON FORGING PRESS

SIR,—Re the article "Precise Control of 3000-ton Forging Press" which appeared in your journal dated August 4, 1961. We note a misunderstanding in the acknowledgments of the above article, where Towler Brothers, Ltd., are credited with the design and manufacture of the thickness control equipment. In actual fact this equipment was designed and manufactured by Brookhirst Igranic, Ltd., Chester, and its use to control forging presses is but one application, of many, to which it can be put.

W. GREGSON

Brookhirst Igranic, Ltd.,
Chester,
August 14, 1961.

A LOCOMOTIVE HISTORY—THE "ATLANTIC"

SIR,—I was very interested to read Mr. E. C. Poultney's article in THE ENGINEER, dated July 28, entitled "A Locomotive History—the 'Atlantic'," and am looking forward to the continuation in which I hope Mr. Poultney will include some data regarding the British "Atlantics," such as those of the G.C.R., G.N.R. and the L.B. & S.C.R. Incidentally I notice that under the illustration Fig. 2 there is an error in the title. Webb's locomotive "Queen Empress" was built at Crewe for the L. & N.W.R. The L.N.E.R. did not exist in 1892. The L.N.E.R. came into being at a much later date when the G.E.R., G.C.R., and G.N.R. and others were amalgamated to form the L.N.E.R.

E. F. GILL

Surbiton, Surrey,
July 31, 1961.

Technical Reports

Aluminium in Railway Rolling Stock. An International Exhibition organised by the Centre International de Developpement de l'Aluminium. London: The Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 21s.—Last June an exhibition was organised at Strasbourg by the Centre International de Developpement de l'Aluminium (CIDA) of which The Aluminium Development Association is a member. The latter has now published the present brochure as a permanent record of a noteworthy event. As noted in the foreword, Great Britain has probably a larger number of aluminium railway passenger vehicles, in service and in project, than any other country. This country took a very active part in the organisation of the Exhibition and was very fully represented by members of the railway world and the aluminium industry. The text includes a note concerning the technical discussions which were an important part of the proceedings. The greater part of the book consists of illustrations, a number being in colour, of the exhibits which are classified as goods vehicles, passenger vehicles, and components. Within each section the illustrations are displayed in alphabetical order of the exhibiting countries. Most of the vehicle photographs are accompanied by section drawings showing dimensions and/or profiles of special sections. Details of the principal alloys are appended. A full list of those present is given at the back of the book.

The Forces Applied to the Floor by the Foot in Walking. National Building Studies Research Paper No. 32. H.M. Stationery Office. Price 3s. 6d. —General-purpose machines for the measurement of abrasion resistance are unsuitable for assessing the resistance of flooring materials to wear by foot traffic. The Building Research Station considers that the most promising approach to providing a suitable machine appears to be to simulate the action of a foot on a flooring material. Thus this reports describes measurements made for this purpose of the forces applied to a floor surface by the foot. A specially designed "force-plate" was used to measure horizontal and vertical forces, and photographic determinations were made, through a glass plate, of the changing area of contact. Special attention was also paid to the problem of slipperiness. In all cases measurements were made both for walking in a straight line and when turning. Various patterns of walking were revealed by the men and women taking part in the tests. These and the other results obtained are summarised ; and the design criteria are given for an abrasion-testing machine for flooring materials, which has been constructed at the Building Research Station and which will be used for further investigations.

Structure of Hardwoods—with Terms, Definitions and Drawings. Part I : Macroscopic Structure. By G. Hart. Information Bulletin B/1B/3. Timber Development Association, 21, College Hill, London, E.C.4. Price 3s. 6d.—This publication presents a series of notes designed to assist students and class instructors to recognise the structural features of hardwoods and to facilitate identification of individual timbers. The text is keyed to over thirty drawings at the end of the booklet. In the first section of the bulletin the author deals in turn with growth rings, pores (vessels), wood parenchyma (soft tissue), and rays, and describes anatomical variations within these major groupings. In a later section timbers exemplifying one or more of some thirty features are listed, and for clear visual identification of types the reader is referred to the appropriate drawing in each instance.

Attitude-Eccentricity Curves and Stability Conditions of the Infinite Journal Bearing. By Leif Floberg. Report No. 15 from the Institute of Machine Elements, Chalmers University of Technology, Gothenburg. Gothenburg : Chalmers University Books/Gumperts, Göteborg ; William Heinemann, Ltd., 15, Queen Street, London, W.1. Price S.Kr.10.—As an extension of work which he carried out in 1957 on oil flow continuity of an infinite journal bearing with axial oil groove, the author presents a more detailed experimental study of boundary conditions and attitude-eccentricity curves.

Lubrication of Two Cylindrical Surfaces Considering Cavitation. By Leif Floberg. Report No. 14 from the Institute of Machine Elements, Chalmers University of Technology. Gothenburg : Chalmers University Books/Gumperts, Göteborg ; William Heinemann, Ltd., 15, Queen Street, London, W.1. Price S.Kr. 10.—The present paper is one of a series of reports on lubrication research carried out at Chalmers University of Technology during the last six years. The author treats the case of hydrodynamic lubrication of two rotating rigid cylinders under a light load and with lubricant of constant viscosity.

Ore Handling at Lysaght's, Scunthorpe

Three types of iron ore are used in the blast furnaces at Lysaght's Scunthorpe Works. One in particular is difficult to handle, and special provision has had to be made to deal with it in the new ore handling installation, which crushes and screens 600 tons of run-of-mine ore an hour.

THE ores used at Lysaght's, Scunthorpe, are Lincolnshire (known as Navvy), Northamptonshire (Northants) and French. Of these the Northants ore is the most difficult to handle, on account of its moisture content, which varies over a wide range, and sometimes exceeds 20 per cent. This ore is, however, produced easily by opencast mining from an ore bed adjoining the works, and as there are large reserves available, it is an economic proposition to use the ore in spite of its poor quality.

All incoming ore is unloaded from rail wagons by means of a G.E.C. 60-ton wagon tippler into a Hadfield two-roll crusher which reduces it to −5in. A second stage of crushing follows, in two Symons cone crushers, and the ore then passes over two Gyrex primary screens. At this point the +2½in rubble can be diverted to the buffer bunker for transfer direct to the blast-furnaces. The −2½in through products from the primary screens are fed to one of four belts by means of two shuttle conveyors, which cross a bridge to the fine screening and tertiary crusher building. Under normal operating conditions two of the belts handle either Navvy or French ores, while the other two carry Northants ore, one belt being used for wet and the other for dry ore. Wet Northants ore has to be dried before it can pass to the fine screening and tertiary crushing section of the plant, and the conveyor carrying this ore passes straight through the tertiary crusher building to a wet-ore stockyard. Here, two dryers are installed which reduce the moisture content of the ore to approximately 13 per cent. The ore is then re-introduced into the system just after the Symons cone crushers in the primary crusher house.

Dry Northants ore is fed to the tertiary crusher building where it passes over two gas-heated Gyrex screens in tandem. Throughs from these screens, which have ¼in mesh decking, go straight to the sinter-material store, and 85 per cent of the oversize is first reduced to −¼in by two G.E.C. Dixie non-clog hammer mills before joining the through products on their way to the sinter-material store.

As the Navvy and French ores are not as sticky as the Northants, no provision is made for drying them. Each of the two conveyors carrying these ores from the primary crusher building feeds Gyrex gas-heated screens in tandem. These screens, which are fitted with ¼in mesh decks, are installed in the tertiary crusher building. An arrangement of collecting belts underneath the screens directs the throughs to a single belt which carries the ore to an appropriate bunker in the sinter-material store. Oversize ore passes through one of three hammer mills which reduces 85 per cent of it to −¼in before it joins the throughs on the way to the sinter-material store. The five hammer mills are supplied with ore by apron feeders located underneath surge bunkers which are kept filled by shuttle conveyors above them. One shuttle conveyor serves the three surge bunkers in the Navvy or French line, and another supplies the ore to two surge bunkers in the Northants line. The hammer mills in the Navvy ore line are fitted with moving breaker plates only; for the Northants ore moving back plates are also fitted. Provision has been made in the layout for installing another hammer mill in the Navvy line and two more in the Northants line at a later date.

There are four separate bulk storage pits for the prepared ores and coke in the sinter-material store, the capacities being Navvy ore 19,000 tons, French ore 7000 tons, Northants ore 13,000 tons and coke 2000 tons. Ore is recovered from the storage pits by the grab of a 12-ton overhead crane, which dumps the reclaimed ore into circular bins supplying variable-speed rotating tables with plough discharge. Two of these table feeders can be used for discharging Navvy ore, two for Northants, two for French ore,

Non-clog hammer mills and apron feeders

General view of ore handling and preparation plant

two for coke and two for flue dust. Provision has been made for the installation of a further four table feeders and bins, two for Northants and two for Navvy ore. The proportions of a sinter mix can be varied by means of the feeders. A typical mix is : Navvy ore 43 per cent ; Northants ore 38 per cent ; French ore 7 per cent ; coke breeze 8 per cent ; flue dust 4 per cent. No provision is made for adding limestone, as the burden is self-fluxing.

Coke is unloaded by a track hopper system into the coke hopper building, which has a capacity of 148 tons. It is extracted from beneath the hopper at a uniform rate of 80 tons an hour by a Sherwen electro-magnetic vibratory feeder, which delivers the coke to a conveyor system terminating in the coke-crushing building. Here the $-\frac{1}{8}$in fraction is screened out and passed by conveyors direct to the sinter-material store. The $+\frac{1}{8}$in coke fraction falls into bunkers, from which it is withdrawn by Sherwen feeders and passed through rod mills set for a product size of $-\frac{1}{8}$in. This product joins the screen throughs going to the sinter-material store.

Materials from the store are carried by a 500ft long belt conveyor joining the sinter-material circular bins and the sinter primary mixing station ; here the materials are mixed in a large revolving drum double paddle-shaft mixer. From this point the raw mix is conveyed via an upper storey in the return fines building to two surge bins and secondary mixers in the sinter-machine building ; distribution to the bins is by means of a reversible belt.

Each surge bin feeds a 168ft long sinter strand through a conveyor and swinging spout, which spreads the raw mix evenly over the strand. Ignition follows, and the mix is sintered in the normal way. On leaving the strands the hot sinter passes through a disintegrator and then over a hot-sinter screen, which removes the $-\frac{3}{4}$in fraction. All oversize passes through a cooler before being taken by a 900ft long conveyor to the blast-furnace bunkers. Dust is collected from beneath the sinter strands by a conveyor and joins the hot-sinter screen throughs. These products are fed by a steel tray conveyor to the hoppers of a conditioning station, through a conditioning drum and then on to a conveyor which returns them to bunkers in a separate building. They are then discharged by table feeders to the raw mix conveyor leading to the primary mixing station. Only $+\frac{3}{4}$in sinter is thus passed to the blast-furnaces ; all undersize is recirculated over the sinter strands.

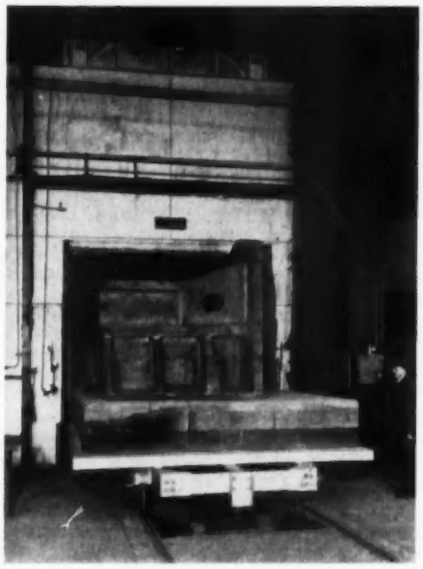
The main contractor for the plant was Head Wrightson Iron and Steel Engineering, Ltd., Thornaby-on-Tees, and the ore handling equipment was sub-contracted to The General Electric Company, Ltd., Erith. Certain equipment was also supplied by G.E.C. through Ross Engineers, Ltd., Surbiton.

Large Electric Stress-Relieving Furnace

WE illustrate an electric furnace built by The General Electric Company, Ltd., Erith, Kent, for the Redcar Iron and Steelworks of Dorman Long (Steel), Ltd. The furnace is of the bogie-hearth or car-bottom type, with a door opening 10ft wide by 7ft high to the spring of the arch, and has a heated length of 20ft. It will accommodate fabrications or castings weighing up to 40 tons and work at a maximum temperature of 1000 deg. Cent.

The furnace walls are of semi-refractory blocks backed with insulating brickwork, and the roof, which is of arched construction, is built up from special semi-refractory shapes backed with insulating brickwork and powder. Heating elements, of nickel-chrome strip, are arranged on the side walls, roof and door. With all the elements in circuit the total rating is 600kW, comprising 60kW on the door and 540kW in four zones of equal length and power in the furnace body. When the temperature reaches 10 deg. Cent. below the required value, the input to the elements is automatically reduced to one third of the maximum rating by means of star/delta contactors housed in the main switchgear cubicle.

Four large-diameter centrifugal fans are provided in the roof of the furnace to increase the rate of heating and to ensure even temperature distribution throughout the charge. Each fan unit is water-cooled and mounted in a heavy fabricated stool bolted to the top steelwork. The impellers and shafts of the fans are made of heat-resisting materials. The furnace door is counterbalanced and is opened and closed by a side-mounted handle and gears. Eccentrically-mounted cams on the door lifting gear ensure tight contact between the machined faces on the door and furnace front plate when the door is closed. Interlocks prevent the furnace from being switched on until the door is fully closed.



Heavy fabrication entering bogie-hearth electric furnace

The furnace bogie is a rectangular steel structure, the top being covered with castable refractory material, held in position by easily removable steel plates. A sand sealing channel is fitted to the two sides and front of the bogie, and at the rear end of the furnace the bogie passes through the back wall so that sealing can be effected from outside. Twelve single-flanged wheels carry the bogie, which is hauled into and out of the furnace by a wire rope and motor-driven winch. An electro-magnetic brake and limit switch stop the motor automatically at each end of the bogie travel.

Four indicating control pyrometers, one for each heating zone, are mounted in the control cubicle, which also contains a six-point graphic recorder. The pyrometers are of the millivoltmeter type, complete with a broken thermocouple protective device. Each instrument is fitted with two mercury switches which are used for controlling the supply to the heating elements.

Interior of furnace : the heating elements and circulating fans are clearly visible

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UNITED KINGDOM OIL PRODUCTION.—The B.P. Exploration Company has made some finds of oil recently and the latest is the discovery of oil in the coal measures at 3600ft at Glenworth near Gainsborough. Other successful drillings discovered a new deposit at Egmanton, and several new producing wells have been completed on the Corringham and Gainsborough fields in Lincolnshire. In 1960 the company's English oilfields produced 85,281 tons, and production in the first six months of this year has totalled 52,000 tons.

SHORTER REPORTS

Fuel Loading Starts at Berkeley and Bradwell

FUEL loading is now in progress on No. 1 reactor at each of the first two commercial nuclear power stations of the Central Electricity Generating Board. These operations were started at Berkeley, Gloucestershire, on August 12, and at Bradwell, Essex, on August 14. Both stations have been designed and built for the C.E.G.B. by The Nuclear Power Group which has its headquarters at Radbroke Hall, Knutsford, Cheshire.

From the start of loading, criticality is expected to be reached in fourteen days at Berkeley (with 660 of the total of 3275 channels filled), and in six days at Bradwell (with 474 of the 2564 channels filled). At Berkeley each channel contains thirteen 19in long fuel elements stacked vertically and at Bradwell each channel contains eight 3ft long fuel elements similarly arranged. The fuel loading of the first charge in each reactor is done by hand, starting with the central channel and proceeding according to a prearranged programme which entails intervals for making reactivity measurements as criticality is approached. After about two weeks of testing to obtain nuclear data relating to the critical core, fuel loading will continue by hand with periodic intervals for partial withdrawal of control rods to establish sustained chain reactions at very low power levels. In this way the two reactors will be loaded with their first full operational charges of fuel.

The No. 1 reactors at Berkeley and Bradwell are expected to start commercial generation of power by the end of this year. When both reactors in each station are in service the net electrical outputs will be 275MW from Berkeley and 300MW from Bradwell.

It will be recalled that the reactors, like the others being built for the C.E.G.B., are gas-cooled and graphite-moderated, the fuel being natural uranium in the form of metallic rods sheathed in finned magnesium alloy cans. The reactor is enclosed in a steel pressure vessel.

A point of interest is that the tender submitted by The Nuclear Power Group for the C.E.G.B's proposed 550MW nuclear power station at Oldbury-on-Severn, Gloucestershire, involves pressure vessels of reinforced concrete.

"Mathematics—Friend or Foe?"

THE first of the annual lectures inaugurated last year by the British Conference on Automation and Computation will be given on September 27, at 5.30 p.m., at the Institution of Electrical Engineers, in London, by Dr. D. G. Christopherson, O.B.E., F.R.S., Pro-Vice-Chancellor of the University of Durham and Warden of the Durham Colleges. He will speak on the subject, "Mathematics—Friend or Foe?" The lecture is open to all members of the thirty-one member societies of B.C.A.C.; others should apply for tickets (free) to the Honorary Secretary, B.C.A., c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

2000MW Power Station, Ferrybridge "C"

THE Minister of Power has consented to the building of the first of two large coal-fired power stations which the Central Electricity Generating Board proposes to build in Yorkshire. The new station (Ferrybridge "C") will be sited on the River Aire and will adjoin the existing Ferrybridge "A" and "B" stations. It will have an installed capacity of 2000MW, the same as that of West Burton, which will be the most powerful steam power station in Western Europe. The main generating plant will consist of four 500MW turbo-alternators and four boilers each with an evaporative capacity of 3,450,000 lb of steam per hour, the steam conditions at the stop valve being 2300 lb per square inch at 1050 deg. Fah., with reheat to 1050 deg. Fah.

Work on site is due to be started in October, the first generating set is programmed to be commissioned in 1965, and the station is due to be completed in 1967, when it will provide an assured market for 5,000,000 tons of Yorkshire coal per annum. This programming has been made possible by the co-operation of the county and local authorities throughout the planning stages. Both of the proposed C.E.G.B. power stations have been approved by the West Riding County Council and by the local authorities concerned. The Minister's decision about the second station, Eggborough, is still awaited.

Quadrupole Amplifier

WITH the introduction of a 400 Mc/s quadrupole amplifier, N1044, the range of these tubes made by The English Electric Valve Company, Ltd., Chelmsford, now comprises three devices covering the 200 Mc/s, 400 Mc/s and 600 Mc/s regions. The N1044 is a transverse field device in which an electron beam interacts with an r.f. field transverse to the normal path of the beam. Under large input signal conditions the tube is cut-off, affording protection to any following stages, and recovery time is extremely short. A gain of 20dB is available with a bandwidth, to 3dB gain points, of 50 Mc/s. Noise is less than 2dB over a bandwidth of at least 25 Mc/s, and the tube has a saturation output power of 50 μW.

The tube is packaged with a focusing solenoid and can be supplied with a power unit providing a d.c. stabilised supply for the solenoid, also d.c. supplies for the tube electrodes and the r.f. pump power. Meters on the front panel show the tube beam current, cathode current, structure current and the electrode voltages. Controls enabling the pump level and pump frequency to be adjusted over set limits are also brought out to the front panel. Inclusion of the power supply unit enables the equipment to be permanently or temporarily included in new or existing apparatus as a low-noise amplifier. Applications of quadrupole amplifiers include radar head amplifiers, input circuits for radio astronomy and tropospheric scatter communications systems, and i.f. amplifiers for millimetre equipment.

[Reply Card No. 1141]

Automatic Voltage Stabiliser

SERVO-MOTOR control of a "Variac" transformer is used in an automatic voltage stabiliser for a.c. announced by Claude Lyons, Ltd., Valley Works, Ware Road, Hoddesdon, Herts. The principle of operation is similar to that of the d.c. power units described in our July 14 issue, page 69, the motorised "Variac" being positioned by a transistorised sensor unit, and its output being arranged to buck or boost the mains voltage. The TS-1 a.c. stabiliser may be set to maintain an output voltage of any value between 200V and 254V. The buck-and-boost transformer has two secondaries, which can be connected in series or in parallel. With parallel connection, a high power rating for the size of equipment is obtained, with range sufficient to compensate for supply voltage variations within the statutory limits of ± 6 per cent. With series connection the same unit provides a wide correction range, covering all likely mains variations even under abnormal conditions. With each connection three different input voltage ranges can be selected by means of tappings on the "Variac." For series connection these ranges are: $-17\frac{1}{2}$ to $+7\frac{1}{2}$ per cent, $\pm 12\frac{1}{2}$, and $-7\frac{1}{2}$ to $+17\frac{1}{2}$ per cent. The correction range in parallel connection is half that for series connection.

The unit is supplied either in a ventilated steel cabinet with lifting handle (TS-1) or as a 19in rack panel with handles (TS-1R). Dimensions of the cabinet model are 13in by 8in by $7\frac{5}{8}$in, while the rack model has a 19in by $8\frac{3}{4}$in panel and a depth behind panel of 8in.

[Reply Card No. 1139]

International Coal Preparation Congress

THE Fourth International Coal Preparation Congress organised jointly by the National Coal Board and the Coal Preparation Plant Association is to be held at Harrogate from May 28 to June 1, 1962. This congress will be open to all engaged in coal preparation technology and industries associated with the extraction and treatment of minerals. About thirty-five papers will be presented and particular emphasis will be placed upon the relationships between feed, composition, plant design and product quality; classification of sizes below $\frac{1}{4}$in; treatment of fine material; and control of plant and products. The three official languages to be used will be English, French and German and simultaneous interpreting will be provided in all three languages. A number of technical visits to collieries and coal preparation plants will be arranged for the delegates. Details of the congress are available from the secretary, Fourth International Coal Preparation Congress, National Coal Board, Hobart House, Grosvenor Place, London, S.W.1.

Proposed New British Standard for Rolled Steel Beams

SINCE the introduction of universal beams in 1958 the number of "I" and "H" rolled steel profiles has risen to seventy-one. Proposals are, therefore, being considered by the British Standards Institution for reducing the range, so enabling the rolling mills to be operated efficiently, with long production runs and minimum costs. If this is achieved, more frequent rolling of all sizes in the list will be possible, deliveries will be quicker, and building design standardisation will be simplified. The British Constructional Steelwork Association, representing the fabricators, is co-operating with the steelmakers, and it is hoped that a new British Standard, reducing the number of sizes to twenty-seven, will be established by the end of this year. This will enable the present British Standard covering sizes and weights of structural steel to be withdrawn on January 1, 1963.

Portable Distillation Plant

A PORTABLE flash distillation plant recently developed by Buckley and Taylor, Ltd., of Castle Iron Works, Oldham, has a rated output of 10 tons per day and is operated by a diesel alternator or from the mains. This "Aquaflash" equipment is made in two portable sections—a flash distillation unit with its pumps and other ancillary equipment and the diesel generator, if required.

In this distillation plant impure water is circulated in series through the tube side of four vapour condensers to progressively raise its temperature. The water is then passed through the diesel engine jacket cooler where its temperature is further increased. Further heat is added in an electric immersion heater vessel before the water is introduced to a train of flash chambers, arranged in series and with progressively reduced sub-atmospheric pressures. The feed water flashes into steam in these four chambers and, in condensing in the associated vapour condensers, serves to provide heat to the incoming feed. Condensate is withdrawn from the plant by an extraction pump and is discharged into suitable storage tanks.

[Reply Card No. 1126]

Double-deck Rail Wagons for Car Transport

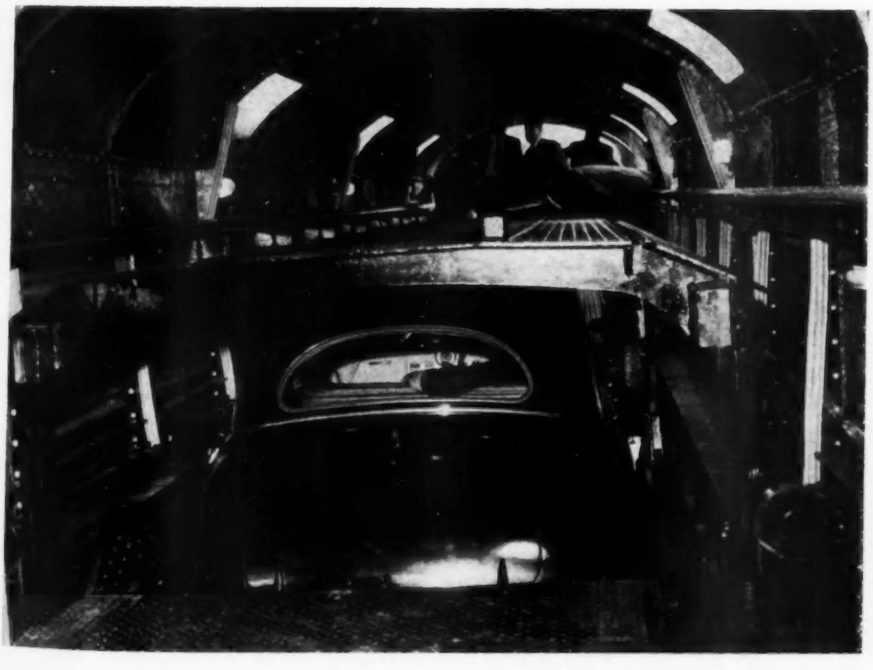
THE first of fourteen double-deck "covered wagons"—ordered by the Eastern Region of British Railways for the car-by-rail route between King's Cross and Perth—will go into regular service shortly. The new vehicles, the first of their kind on British Railways, were designed and built by Newton Chambers and Co., Ltd., of Sheffield, in conjunction with the Chief Mechanical and Electrical Engineer, Eastern Region.

The new vehicles are 64ft 1in over buffers, 12ft 10in high and 8ft 8¼in wide, and are designed to carry a load of 12½ tons. They have a tare weight of 32 tons and can negotiate curves of 1¾ chains. Each vehicle has its body and roof built up of five reinforced "Fibreglass" panels which are bolted together. The use of glass fibre for the body has the advantages of lightness good finish and obviating the need for painting as the material is self-coloured in B.R. standard maroon livery. The body panels bolted to the frame structure are mounted on rubber supporting pads to eliminate vibration. The panels were supplied by the Sheepbridge Equipment Company, Chesterfield. Bogies, specially designed to enable the vehicles to travel at express speeds, have single bolster suspension and roller bearing axleboxes. In addition to standard automatic vacuum braking the vehicles are fitted with Westinghouse air brake equipment to enable them to run on Continental services.

The wagons are arranged to accommodate a full line of cars along the top floor and two cars on a lower floor formed in a well section between the bogies. Two lifts are provided for loading cars on the lower floor and for loading purposes the two lifts are raised to bring their platforms level with the top floor. In the loading sequence the first two cars are driven up an inclined ramp provided at terminals and placed in position on the lifts. The lifts are then lowered, as shown in our illustration, and their roofs provide a deck flush with the top floor. The full length of the top floor is then available for the storage of cars.

A number of these vehicles can be loaded with cars at the same time by use of a drop-down platform which connects the top floor of each vehicle, making a continuous flush deck for loading one vehicle from the next along a train.

The lifts are suspended on wire ropes and are operated through these ropes by a hydraulic ram to which pressure fluid is supplied by a small motor-driven pump. Power supply sockets are provided on each truck for connection to a mains supply, and in emergency the pump can be operated by hand.



Interior of two-tier transporter showing car descending on lift to lower deck

Grinding Carbide Turning Tools*

A REPORT has just been issued by the Production Engineering Research Association giving the results of a comparative study of grinding methods for carbide turning tools. This subject is of widespread interest in industry, and we abstract below the conclusions reached as a result of the study and the recommendations. The report itself gives comprehensive details of the work and equipment involved.

As most carbide tools used in this country are ground on off-hand machines, equipment of this type was used throughout the investigation to keep the conditions as near as possible to industrial practice. The types of grinding wheel, grits, grades and bonds selected for the tests were considered typical of those commonly used in industry.

OBJECT OF THE STUDY

(1) To determine, when turning alloy steel, the effect on the performance of carbide tools ground with

(*a*) a 120 grit metal bonded diamond wheel ;
(*b*) a 60 grit silicon carbide wheel (rough ground) and a 120 grit silicon carbide wheel (finish ground) ;
(*c*) electro-spark erosion (rough and finish ground);
(*d*) a 60 grit silicon carbide wheel ;
(*e*) a 60 grit silicon carbide wheel (rough ground) and a 120 grit metal bonded diamond wheel (finish ground) ;
(*f*) a 60 grit silicon carbide wheel (rough ground) and a 180 grit silicon carbide abrasive belt (finish ground).

(2) To determine the rate of removal of cemented carbide when grinding tools by the following methods:
(*a*) on a metal bonded diamond wheel ;
(*b*) on a silicon carbide wheel, dressed with diamond and star-wheel dressers ;
(*c*) by electro-spark erosion.

CONCLUSIONS

(1) The tests showed no marked differences in tool life for the various methods of grinding.

(2) The rate of removal of cemented carbide was greatest when tools were ground on a 120 grit metal bonded diamond wheel. Electro-spark erosion and a 60 grit silicon carbide wheel gave a similar rate of carbide removal.

(3) A silicon carbide wheel dressed with a star-wheel dresser gave faster carbide removal rates than the diamond dressed wheel.

(4) The grinding rate of the silicon carbide wheel decreased rapidly after the initial dressing.

* Production Engineering Research Association, Melton Mowbray, Leics. Report No. 49. Price 7s. 6d

Abrasive belt grinding of carbide tools which was mainly a lapping operation carried out in conjunction with silicon carbide wheel grinding appeared to have no particular advantage over other methods. One limitation was the difficulty of grinding the rake face of the carbide tool, as this could only be done using the extreme edge of the belt.

RECOMMENDATIONS

When grinding carbide tools, a metal bonded diamond wheel should be used. This recommendation is based on the results of tests in which a limited number of grinding media were used. It is possible that other types of diamond and silicon carbide wheels of different grades, grits, and bonds would give comparable rates of cemented carbide removal, but factors such as surface cracking and grinding wheel wear would also have to be considered.

Liquid Filters

THE recently introduced 1¼in and 1½in types of "Airpel" filters for liquid fuels, water, &c., made by British Steam Specialties, Ltd., Fleet Street, Leicester, are, as can be seen from our illustration, designed on particularly clean lines. These filters each weigh only 6 lb and are made for working pressures up to 50 lb per square inch. They comprise two aluminium alloy die castings—a body and a cover coupled together with three wing nuts—containing a filter element which withdraws with the cover. An "O" ring seal is provided between the cover and body and the tapped inlet and outlet branches are on the same centre line.

Easily cleaned filter with a working pressure of 50 lb per square inch

Elements, which are easily cleaned, are made in two types for primary and secondary filtering duties. The primary elements of perforated plate are available in five forms with from eleven to 265 holes per square inch. The eight forms of secondary filter elements, in wire mesh on perforated plate, have from twenty to 200 square mesh gauze with a range of apertures from 0·032in to 0·0029in.

[Reply Card No. 1134]

Abuse-resistant Heat Source

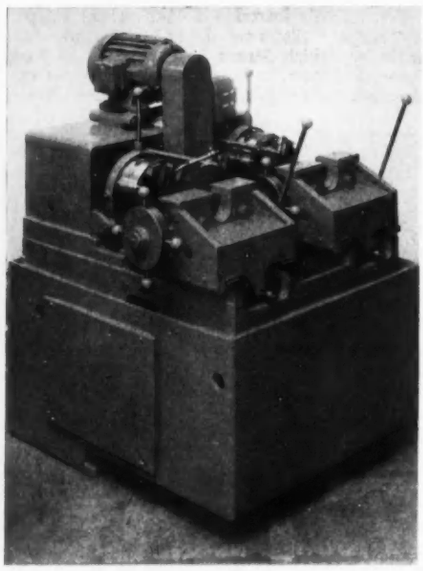
HEATER panels of thermo-setting resin impregnated asbestos—"Durestos"—have been developed by Turner Brothers Asbestos Company, Ltd. The panels have incorporated a resistance heating element supplied by Thomas French and Sons, Ltd., and have dissipated 500W per square foot at 80 deg. to 90 deg. Cent. "Durestos" is best cured under pressure, but flat sections can be moulded without applying pressure. These mouldings have functioned even under water, and are expected to find applications as heaters or towel racks in bathrooms, as plate racks or food warmers, and in incubators or brooders. The mouldings can accept most surface finishes or can be self-coloured.

[Reply Card No. 1132]

SHORTER REPORTS *(Continued)*

Double Spindle Threading Machine

THE illustration below shows a double spindle threading machine for bolts or pipes up to 1½in which is made by Landis Machine-Maiden, Ltd., Hyde, Cheshire. A 5½ h.p. motor drives the spindles through vee belts and pick-off gearing at the rear which gives a choice of eight spindle speeds and enables each spindle to be run at a different speed when threading two classes of workpieces. The Landis die heads used on the machine are provided with an automatic trip mechanism which is adjusted in accordance with



Double spindle threading machine for work up to 1½in diameter

the required thread length to be cut. Die heads can be closed either by the rearward movement of the work carriages or by hand levers.

The work carriages run on renewable hardened and ground ways which are covered at the front to prevent damage by swarf. These carriages have clamping fronts which are adjustable vertically and horizontally to align the work with the die heads. An effective grip on workpieces is provided by a hammer blow handwheel and alternatively pneumatically operated fronts can be fitted on the carriages. The carriage traverse of 6in can be lever operated or through a rack and pinion by handwheel.

The machine base incorporates provision for the collection and storage of substantial quantities of cuttings. Coolant is delivered to the heads by a motor-driven pump from an 8-gallon tank.

[Reply Card No. 1136]

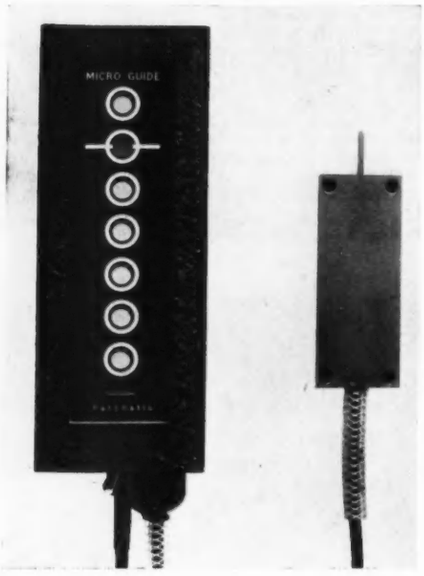
Corrosion Resistant Tantalum

IT is known that the lack of suitable materials has often prevented the commercial development of a new chemical process which has proved successful in the laboratory. Often in existing processes maintenance costs are high because the common metals and alloys in use in the plant are affected by corrosive acids and high temperatures. Search is being made to discover new metals able to resist attack and one of the most promising is tantalum, a bluish grey metal which is similar to platinum in appearance and to glass in its resistance to corrosion ; it belongs to the rare metals group and this together with the complicated recovery process makes its cost high. Ways of using the metal in the chemical industry are being sought in the Amsterdam laboratory of Royal Dutch/Shell, particularly as a liner for pressure vessels where, used as a thin internal coating, the cost would not be prohibitive. Besides the present lack of know-how regarding fabrication, the metal cannot be welded in air because it becomes brittle and when welded to other materials the bond is imperfect.

To overcome the welding problem Shell engineers have adapted the technique of welding in an inert gas, argon, as used for welding titanium, but the system calls for more accurate control of welding conditions since the melting point of tantalum is about 5425 deg. Fah., and it has a tendency to warp. Provision is also made to protect the back of the weld with argon. Provided that all parts of the joint are shielded with argon, simple welds can be made in the open, but an argon-filled welding box is recommended for the welding of more intricate shapes. For attaching a tantalum liner to a steel vessel methods are being developed similar to those employed for titanium linings where strips of titanium are riveted to the inside of the vessel and the lining panels are attached to the backing strips by spot welding and interconnected by overlapped fusion welds.

Indicator for Repetitive Machining

AN equipment which can be fitted to a machine tool engaged on repetition work for the purpose of clearly indicating the reducing dimensions in the final stages of metal removal has been developed by Paramatic Development, Ltd., Canal Street, Derby. This equipment, known as the " Micro-Guide," consists essentially of a micro-head—the lever of which contacts the particular slide or tool being fed into the work—and an indicator panel which through a succession of lights shows the feed increments registered by



Micro-head and indicator for showing reducing dimensions during final cuts in repetition machining

the lever movement. A micro-head and panel can be seen in the accompanying illustration.

The indicator panel, arranged for connection to a single-phase power supply, can be fixed in any desired position. It has seven windows which are illuminated in turn to show predetermined stages in the finish machining operation. The micro-head is a compact sealed unit about 4in long with a gauge lever projecting from one end and it is coupled by a cable to the indicator panel ; fixing holes are used to secure the head in place on a machine and when the gauge lever is deflected in either of two opposite directions it controls electrically the lights in the indicator panel windows.

In a machining sequence roughing cuts are taken until the lever is contacted at 0·025in above the finished size and this contact illuminates the lowest (green) window of the indicator. This green light provides a warning during subsequent advance up to within 0·005in of the finished size. From then onwards each 0·001in advance is successively indicated by the illuminating in turn of the (amber) windows above on the panel. At the attainment of finished size on the final 0·001in advance a red window is illuminated. Should the feed over-run by 0·001in a blue window at the top of the panel is lit.

The equipment can be used on a variety of machine tools and, once set by the machining of an initial master workpiece, it enables repetitive machining of subsequent components to the same limits. If required a second micro-head can be plugged into an indicator to control another finish machining sequence on a component at the same setting.

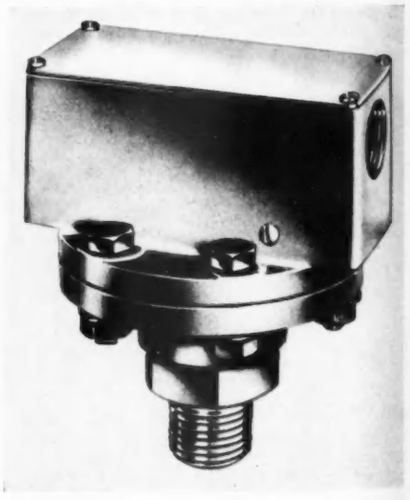
The maker points out that these equipments have many other applications where continuous repetition work or comparisons to fine limits are involved. They have been used with success on collective sizing and grading work, continuous monitoring of automatic machining processes and on work positioning in figures.

[Reply Card No. E1137]

Variable Differential Pressure Switch

THE range of variable differential pressure switches made by Bailey and Mackey, Ltd., Baltimore Road, Birmingham, 22, has been extended by the introduction of a medium pressure model for maximum pressures up to 150 lb per square inch. Its operating range covers a minimum differential of 3 lb per square inch and a maximum differential of 145 lb per square inch, and the accuracy of the pre-set differential is stated to be within 1 per cent of maximum pressure.

In this instrument, illustrated below, the variable differential is provided by an adjustable controlled spring arrangement between a diaphragm and switch. The differential is altered by the rotation of a wheel inside the case and the switch is adjustable by a nut.



Variable differential pressure switch for a maximum pressure of 150 lb. per square inch

The switch has three terminals, one common, one normally open and one normally closed; thus two circuits are provided, one to close and the other to open at the set pressure. For corrosive chemicals the pressure chamber of the switch can be lined with " Neoprene " or the diaphragm fitted can be made from spring steel, stainless steel or beryllium copper in accordance with the required duties.

[Reply Card No. 1138]

Remotely Controlled Lathe for Turning Tensile Test Pieces of Irradiated Uranium

With the help of the Production Engineering Research Association (P.E.R.A.) the U.K. Atomic Energy Research Establishment at Harwell has developed a method of speeding up the preparation of test specimens machined from irradiated uranium. These specimens are required for experimental determination of the mechanical properties (such as tensile strength) of uranium irradiated in nuclear reactors. The machines used to produce these specimens must be installed in special cells provided with heavy shielding to protect the machine operator from radiation hazards. Remote control of the machines is usually exercised through mechanical manipulators worked by the operator from outside the cell. However, this method of machining the specimens is both fatiguing and slow. It takes nearly a day to machine a test specimen about ½in in diameter by 2in long. The Atomic Energy Research Establishmen ttherefore asked P.E.R.A., Melton Mowbray, to collaborate in designing, developing and manufacturing a special-purpose lathe, operated by remote control, which would greatly reduce the machining time and at the same time eliminate operator fatigue. A special copying lathe which will reduce the machining time to thirty minutes has now been designed and built by P.E.R.A. and has been undergoing simulation tests at Harwell before machining tests are carried out on irradiated material.

The design of the lathe had to meet a number of special requirements. For example, the need to enclose the cutting area completely, to prevent radioactive swarf and cutting fluid escaping into the surrounding space, restricted the movements of the toolpost and made sealing difficult. Exceptional rigidity was required in the structure and in the holding arrangements for the tool and the workpiece. To achieve the high dimensional accuracy and fine surface finish required in the finished test specimen the working temperature during machining had to be kept to a minimum. There was insufficient reliable data on the optimum cutting conditions, type of tool and cutting fluid for machining irradiated uranium. Therefore machining experiments had to be conducted to determine the most suitable machining cycle. In these experiments tests were made on a range of materials, including cast iron, stainless steel and national uranium.

Initially the proposed design was based on a special-purpose lathe arranged for mechanical control through the cell walls. However, it soon became apparent that this method of operation would not provide adequate control of the lathe functions outside the cell. The design specification was therefore reconsidered and it was decided that, except for one or two simple controls, all lathe functions should be controlled outside the cell from a console desk which could be located at a distance of up to 25ft from the lathe itself, the console and the lathe being connected by a plug-in cable harness.

The final design incorporates a modified standard type headstock mounted on its side. A 3 h.p. motor-driven speed unit provides infinitely variable spindle speeds between 380 and 3300 r.p.m. when the spindle is direct driven, and 40 to 350 r.p.m. when driven through gearing. A two-jaw remotely controlled air chuck will accommodate the full range of raw material shapes from which the test specimens will be produced.

The profile to be machined is controlled by a mechanical copy follower attachment used in conjunction with a built-in remote-reading gauging head. The irradiated material is machined inside a sealed chamber which retains radioactive swarf and contaminated cutting fluid; the front of the chamber is made of clear polystyrene to enable the cutting operation to be observed. A twin-head air gauge is attached to a pantograph arm for measuring the diameter of the test piece. The air-operated toolpost incorporates a quick release toolholder which is indexed from the console. Indexing the toolholder automatically indexes the motor-driven stop system, although these movements can also be controlled separately from the console. The lathe's copying system is engaged remotely by a toggle mechanism which releases the leadscrew and permits it to move under the action of an air cylinder until the stylus engages with a template.

The forward and return traverse of the saddle is smoothly variable up to a speed of 15in per minute using a variable-speed, geared d.c. motor controlled by a "Variac" operating through a rectifier. The cross-slide leadscrew is driven by a d.c. servo-motor through a gearbox and recirculating ball spline, the motor being controlled by magslips from the control console.

The tailstock, which has the same traverse rate and is under the control of the same system as the saddle, is fitted with a collet quill operated by a pneumatic cylinder. A stall torque system is incorporated to prevent the running centre being overloaded, but to permit drilling operations to be carried out at full torque.

As previously mentioned, all the principal functions of the lathe are controlled from the console. Press-button switches in the centre of the panel control the main drive motor, the oil pump and cutting fluid pump. The toolpost indexing, spindle clutch brake, chuck, saddle and tailstock movements, the engagement of the copying system and tailstock collet are also controlled by the console.

The cross-slide traverse is varied by means of a handwheel situated on the front face of the console. The wheel has 250 graduations, each graduation being equivalent to 0·001in of workpiece diameter.

Production Data Recording

Centralised monitoring of production processes is provided by the "Productograph" system now being marketed in Great Britain by Adrema, Ltd., Telford Way, London, W.3. The system feeds signals to a console unit consisting of an assembly of instruments responsive to impulse generators such as microswitches, photoelectric cells, flow switches, microphones, or other devices according to the information required. From twenty to 200 sources of information may be connected to the console, which consists of several units. A linear counter continuously shows required and actual production, alongside counters presenting individual machine production and idling times. This information is also integrated for up to 200 machines. A further unit presents on an illuminated panel an instantaneous overall view of the operation of every production unit at any time.

The heart of the system is the recorder, on which the causes of interrupted production are also shown. These are conveyed by the machine operator pressing one of five buttons at his station when a warning light operated from the transducer on his machine shows him that production has been interrupted. This signal also appears at the console. Telephone facilities are provided from the console to machine operators, production managers and others, and conversations or instructions can be recorded and played back as required. A timer enables the whole installation to be switched on and off automatically.

[Reply Card No. 1108]

Single Point Tanker Loading Buoy

A prototype single point loading buoy has been sited at a position some 3½ miles off the coast at Miri, Sarawak, to provide a loading berth for ocean-going tankers. Built by Werf Gusto N.V. Holland, in consultation with Shell marine and engineering advisers, the berth is owned and operated by Sarawak Shell Oilfields, Ltd., and caters for the simultaneous handling of crude oil and bunkers. Purpose constructed jetties in association with adequate port services solve the problem of berthing large tankers, but there are many places where sheltered berths cannot be made available either because of physical obstacles or prohibitive costs. Under these circumstances multipoint moorings have been used, at points distant from the shore, to secure tankers for the loading or discharging of cargoes through submarine pipelines. Such systems have some of disadvantages and are affected in their operation by tidal and weather restrictions. It was from these considerations coupled with increasing size of tankers that the idea was conceived of operating single point loading/discharging terminals in the open sea. The concept was that a ship could be moored to a buoy by the bow, thus allowing for swinging so that the hull presents the least resistance to wind, weather and tidal forces. Loading or discharging was to be through floating pipelines swivelled at the centre of the buoy and thence to the shore through submarine pipelines. Model tests carried out in the Netherlands Ship Model Basin at Wageningen indicated the theoretical soundness of the concept and Sarawak Shell Oilfields, Ltd., was requested to field-test a prototype buoy at its Miri terminal, which was particularly suitable for such tests, due to the off-shore weather conditions obtaining. The prototype, 27ft in diameter, weighing 65 tons, moored by eight 10-ton anchors and equipped to handle two grades of oil through three 12in floating pipelines, was tested during 1960, and after making certain modifications as indicated by the tests, the buoy has been relaid and is now in service for loading crude oil and bunkering.

Low-Temperature Resistance Thermometers

Development by its American associate of low-temperature resistance thermometer sensing elements for the range 4 deg. to 40 deg. K is announced by Honeywell Controls, Ltd., Greenford, Middlesex, through whom these components can be obtained. The sensors use the temperature-dependence of resistance in doped germanium and are designed for high sensitivity in the liquid hydrogen range, the change of resistance with temperature being from 1000 ohms to 10 ohms between the limits named. Two forms of sensor are available, one for surface temperatures and the other, of probe shape, for internal applications. Both are encapsulated and hermetically sealed. Used with a precision power source, the signal is sufficient for operating conventional indicating and recording potentiometers. Separate current and potential contacts are provided so that long-term stability will be unaffected by fluctuations in contact performance. Dimensions of the sensors, excluding leads, are approximately ⅜in diameter and ¼in deep for the surface model and $^{5}/_{32}$in diameter by ¼in long for the probe.

[Reply Card No. 1113]

Launches and Trial Trips

Moledet, passenger liner; built by Ateliers et Chantiers de Bretagne for Zim Company (Israel); length between perpendiculars 373ft, breadth 59ft 8in, depth to "A" deck 35ft, draught 19ft 8in, deadweight 2150 tons, displacement 6000 tons; passengers 616; two S.E.M.T.-Pielskick nine-cylinder diesel engines driving one shaft, 6390 maximum horsepower at 430 r.p.m., 4600 normal horsepower to give 17 knots. Trial, July.

Pentellina, self-trimming ore and coal carrier; built by Ateliers et Chantiers de la Seine Maritime for Compagnie Nantaise des Chargeurs de l'Ouest/Union Navale; length between perpendiculars 507ft 11in, breadth moulded 68ft 11in, depth 43ft 8in draught 30ft 1in, deadweight 17,500 tons; four holds; three 335kVA diesel-driven alternators; Creusot-Burmeister and Wain two-stroke, single-acting, supercharged diesel engine, six cylinders, 7500 h.p. and 115 r.p.m. Trial, June.

British Cormorant, oil tanker; built at Belfast by Harland and Wolff, Ltd., for B.P. Tanker Company, Ltd.; length between perpendiculars 495ft, breadth moulded 69ft, depth moulded 37ft; deadweight 15,400 tons summer draught, twenty-seven cargo oil tanks, two pump rooms; three 250kW diesel-driven generators, one 75-ton steam-driven generators; Harland and Wolff six-cylinder pressure induction two-stroke opposed-piston oil engine. Trial, July 6.

George Peacock, oil tanker; built at Belfast by Harland and Wolff, Ltd., for The Pacific Steam Navigation Company, Ltd.; length between perpendiculars 610ft, breadth moulded 80ft 6in, depth 45ft 6in, deadweight 28,800 tons; nine sets of three cargo oil compartments, one main cargo pump room; one 240kW diesel-driven generator and two 150kW steam-driven generators; Harland and Wolff single-acting, pressure induction, two-stroke opposed piston diesel engine, seven cylinders 750mm bore by 2000mm combined stroke, 112 r.p.m. Trial, July 6.

INDUSTRIAL NEWS

Iron and Steel

Iron and steel production in the United Kingdom during July, affected as is usual by the holidays, was at an average rate of 380,200 tons a week compared with 447,500 tons a week in June. The July production was 3 per cent less than in July, 1960. Production of pig iron was also lower, reaching an average of 276,600 tons a week compared with 297,400 tons a week in June and with 288,900 tons a week in July, 1960.

The Iron and Steel Board has estimated that stocks of steel held by users and merchants fell by about 80,000 tons or nearly 2 per cent during the second quarter of this year. There was also a further substantial fall in stocks of sheet. Stocks of tinplate also fell, the Board says, but there was a rise in the stock of plate. Stocks of other types of steel, it adds, fell by about the average of 2 per cent over the whole field. From the figures so far available, the Board estimates that the use of steel in the home market during the second quarter amounted to a seasonally-corrected figure of 3,690,000 tons.

Deliveries of steel to the mechanical engineering trades were substantially higher in the first half of the year than a year ago, the increase being associated, the Board says, with greater capital investment in home industries and increasing exports of engineering goods. Some parts of the engineering trades were, however, taking rather lower deliveries of steel during the second quarter. Manufacturers of contractors' plant took less, and the building and structural steelwork industries, although so far this year taking substantially more steel than a year ago, showed a slight fall in the second quarter of 1961 compared with the first quarter. Deliveries to the motor vehicle industry were well below the figures for last year, the Board states, although there has recently been some revival following the increase in production of motor cars from the low level reached during the early part of the year.

According to the latest figures issued by the Iron and Steel Board, the United Kingdom is continuing to increase its share of the world trade in steel in spite of some recent reduction in the total trade. Provisional figures for the period January to March, 1961, show that of exports of 4,547,000 tons of steel from main exporting countries, the United Kingdom's share was 16·9 per cent.

Conditions in Steel Foundries

The first report of the Joint Standing Committee on Conditions in Steel Foundries has now been published. Set up in 1952, the committee continued the work of the Committee on Dust in Steel Foundries, which was appointed in 1943, and reported twice, in 1944 and 1951, indicating on the latter occasion that there was still much work to be done. The present report, entitled "Conditions in Steel Foundries" (H.M. Stationery Office, 10s.) details the work done by the committee during the last seven years, and emphasises the fact that although the "task is by no means ended," much useful information has been collected, which should be given the widest possible publicity, and that the preventive measures devised should be put into practice in the industry at once.

A large part of the work of the committee has been on the prevention of industrial diseases in steel foundries by the elimination, suppression or control of dust or fumes, but due attention has also been paid to accident prevention. From an examination of the industry's accident statistics during the period 1953–56, the committee concluded that a determined attack on the principal causes of accidents could bring about a very substantial reduction. The committee recommends, in particular, a higher standard of housekeeping, which includes the provision of better floors and gangways; wider provision of protective clothing and equipment and the necessary corollary, its proper use by workpeople; good first-aid services; and better training and instruction in safe methods. For such efforts to be successful there must obviously be keen interest and determination by both management and workers, and the committee feels that there is room for improvement in this connection. A useful start can be made by the establishment of a safety committee, with equal representation from management and men. Such bodies exist in many works, but the committee is of the opinion that some of the safety organisations could do with rejuvenation, and that there is much new ground to be broken.

Unemployment Insurance Agreement

The Ministry of Labour announces that the reciprocal Unemployment Insurance Agreement (H.M. Stationery Office, 6d.) which the United Kingdom concluded with the Federal Republic of Germany on April 20, 1960, has been ratified and will come into force on September 1, 1961. The Agreement covers unemployment benefit provided under the National Insurance Scheme and the corresponding scheme in the Federal Republic, and enables an insured person who becomes unemployed in one country and claims benefit there, to count any contributions paid in the other country. A separate Agreement covering the other social security benefits of the two countries came into force on August 1, 1961.

Reciprocal Social Security Agreements are already in force with the following countries: Australia, Belgium, Canada, Cyprus, Denmark, France, Finland, Guernsey, the Irish Republic, the Isle of Man, Israel, Italy, Jersey, Luxembourg, Malta, the Netherlands, New Zealand, Northern Ireland, Norway, Sweden, Switzerland, Turkey and Yugoslavia.

Agricultural Engineering

According to the latest report issued by the Agricultural Engineers Association the trend in agricultural engineering production home sales and exports continues to be favourable to the industry as a whole. Output showed a slight improvement during June as compared with last year, and total production for the first six months of 1961 was 2 per cent higher than in the first six months of 1960. Home sales during the first half of this year were 11 per cent greater than in the corresponding period of last year, whilst export sales for the first six months showed a 3 per cent rise compared with the first six months of 1960.

Following Great Britain's formal application to join the European Economic Community, the Association says in its current *Trend Review* that it must be regarded as probable that Britain will start cutting existing tariffs before Common Market membership becomes a fact. At present, it adds, the "Six" have reduced their tariffs internally by 30 per cent, and by the time of Britain's prospective accession the figure will have reached 40 or possibly 50 per cent. As it would be difficult to bring British levies down by as much as 50 per cent overnight, some initial cuts should be expected, the Association suggests, before that time is reached. If this is done, however, the cuts would almost certainly be extended on a non-discriminatory basis to all Britain's trading partners, the Association thinks, and might even be undertaken unilaterally. But the equally clear possibility exists that the next round of cuts by both the European groupings will be extended by each to the other, the Association says, thus eliminating the prospect of the British market being opened up to more intense competition before similar opportunities are created in Europe.

Training in Electrical Engineering

The British Electrical and Allied Manufacturers' Association has just issued a revised edition of its booklet "Scholarships and other Awards available to British Students for training in Electrical and Allied Engineering." The booklet was prepared under the auspices of the BEAMA Education Committee and its object is to focus attention on the considerable help available through scholarships and grants to young persons whose inclinations lean towards a career in engineering, particularly in electrical engineering.

Part one of the booklet gives details of scholarships and other awards open to non-graduates, chiefly those leading to a first degree in electrical engineering; part two gives particulars of post-graduate scholarships and research awards open to senior students for advanced work in electrical engineering and allied subjects; and part three gives details of scholarships and awards permitting study abroad for both graduate and undergraduate students.

The aim has been, the Association says, to include in the booklet all open scholarships designed specifically for study in electrical engineering and to list as many as possible of the general awards which are not restricted as to subject and may be used for training in electrical engineering, but the booklet does not claim to exhaust the subject.

PERSONAL AND BUSINESS

Appointments

MR. E. V. SMALL, who joined the board of Boving and Co., Ltd., on May 11, has been elected chairman of the company.

COCHRAN AND CO., ANNAN, Ltd., states that Mr. Hugh M. Simpson has been appointed chief engineer of the company.

MR. D. H. YOUNG, A.M.I.Mech.E., is to join the staff of Hale Hamilton (Valves), Ltd., on September 1, as general sales manager.

MR. G. F. LAURENCE, director of technical services at Metalastik, Ltd., has been appointed a deputy managing director of the company.

THE INCANDESCENT GROUP OF COMPANIES has appointed Mr. W. S. Sinclair to be manager of its Cardiff office, as from the beginning of August.

DR. C. J. JACKSON, of the Distillers Company, Ltd., has been appointed a member of the Central Advisory Water Committee for England and Wales.

THE MINISTRY OF AVIATION announces the appointment of Mr. D. A. Lovelock as principal private secretary to Mr. Peter Thorneycroft, Minister of Aviation.

MR. G. D. TAYLOR, formerly head of the flight research department of the Bristol Aircraft Company at Filton, has joined Epsylon Industries, Ltd., as chief applications engineer.

MR. G. V. COX has been appointed general manager of sales, plastics products, of Monsanto Chemicals, Ltd., and MR. M. W. WAUGH, general manager of sales, chemical products.

BRITISH INTERNAL COMBUSTION ENGINE MANUFACTURERS' ASSOCIATION has appointed Mr. H. Desmond Carter, M.I.Mech.E., M.I.Mar.E., to be its chairman for the coming year in succession to Mr. L. P. Lee. Mr. C. F. Barnard, M.I.Mar.E., M.I.E.I., has been appointed vice-chairman.

MR. P. HOYLE has been appointed to the board of Rownson Conveyors, Ltd., one of the Baker Perkins group of companies. He retains his appointment as deputy manager of the bakery machinery department of the parent company and will continue to operate from Westwood Works, Peterborough.

THE IRON AND STEEL INSTITUTE announces that the Council has decided to nominate Mr. M. A. Fiennes, M.I.Mech.E., group managing director of Davy-Ashmore, Ltd., at the Institute's autumn general meeting on November 29, 1961, for election at the annual general meeting on May 2, 1962, as President for 1962–63.

MR. H. W. A. WARING, general managing director and deputy chairman of GKN Steel Company, Ltd., has been elected honorary treasurer of the Iron and Steel Institute, in succession to Sir Julian Pode, deputy chairman and managing director of the Steel Company of Wales, Ltd. Sir Julian, who has served as honorary treasurer since 1959, has been elected a vice-president of the Institute.

MR. LAURIE WOODHEAD, director and general manager of Cossor Instruments, Ltd., and past president of the Scientific Instrument Manufacturers' Association of Great Britain, has accepted the chairmanship of the Organising Committee of the International Instruments, Electronics and Automation Exhibition, (to be held at Olympia, London, from May 28 to June 2, 1962), owing to the recent death in Switzerland of Mr. Philip Canning, the chairman.

NUCLEAR DEVELOPMENTS, Ltd., a private company recently formed by Imperial Chemical Industries, Ltd. (Metals Division), Rolls-Royce, Ltd., and The Rio Tinto Company, Ltd., to process and manufacture nuclear fuel materials and to fabricate reactor fuel elements, has appointed the following board of directors : chairman, Mr. J. N. V. Duncan, managing director, The Rio Tinto Company, Ltd., Mr. R. W. Wright, deputy managing director, The Rio Tinto Company, Ltd., Sir Mark Turner, director, The Rio Tinto Company, Ltd., Mr. J. D. Pearson, chief executive and deputy chairman, Rolls-Royce, Ltd., Mr. A. A. Rubbra, director, Rolls-Royce, Ltd., Mr. L. Barman, special executive, Rolls-Royce, Ltd., Dr. J. Taylor, director, Imperial Chemical Industires, Ltd., Mr. St. J. de H. Elstub, chairman, I.C.I. Metals Division, Dr. R. L. P. Berry, director, I.C.I. Metals Division. Mr. S. S. Smith, research manager, I.C.I. Metals Division, has been appointed executive director and general manager. Mr. P. J. G. Elwes, The Rio Tinto Company, Ltd., has been appointed secretary.

Business Announcements

THE BOWATER PAPER CORPORATION, Ltd., Bowater House, Knightsbridge, London, S.W.1., announces that the name of Flexpipe, Ltd., a subsidiary company, has been changed to Bowater Flexpipe, Ltd.

FURNASCOTE, Ltd., 16–18, Malvern Road, Southampton, states that in future it will manufacture and market Furnascote refractory coatings formerly manufactured and marketed by Corrosion, Ltd., Southampton.

MR. D. R. WALKER, has been appointed secretary of the Vitreous Enamel Development Council. The registered offices of the Council have been transferred from 11, Ironmonger Lane, London, E.C.2., to 28, Welbeck Street, London, W.1. (telephone Hunter 2237).

THE Napier " Spraymat " electrical de-icing system is to be manufactured in Japan by Shin Mitsubishi Heavy Industries, Reorganized, Ltd., of Tokyo. Production of " Spraymat " will commence in Japan early next year, initially to equip the Lockheed F.104J " Star fighter," which is being manufactured by Shin Mitsubishi for the Japanese Air Defence Force.

ELLIOTT BROTHERS (LONDON), Ltd., 34, Portland Place, London, W.1., a member of the Elliott-Automation Group, has negotiated with the Office National d'Etudes et de Recherches Aeronautiques (O.N.E.R.A.) of France a licence to manufacture and sell two gas analysis instruments of advanced design. The analysers are of the paramagnetic type, a principle used in both thermo-pneumatic and thermo-magnetic convection systems of measurement.

MR. W. N. COLLINS, M.I.Mech.E., is resigning as assistant managing director of F. Perkins, Ltd., and from the company's board and the boards of its subsidiary companies, on which he serves, with effect from July 24, 1961. Mr. Collins reaches the retirement age within the group early in 1962 : it is not intended that his connection with the group should be entirely severed immediately, but that the burden of his duties should be gradually lightened.

THE DAVID BROWN CORPORATION (SALES), Ltd., states that with effect from August 14, its Manchester office will be located at Ashburton Road, Trafford Park, Manchester 17 (telephone, Trafford Park 4751–2). This move is to be made coincident with the transfer of the company's machine tool division to these premises from Britannia Works, Sherborne Street, Manchester. The office handles sales of all products of the David Brown Gear and Foundry Groups.

THE CAMP BIRD GROUP OF COMPANIES announces the opening and start of production of a new £500,000 factory in West Germany, for cold forging plant. It is a member of the International Cold Forging Group whose factories are situated at Ravensburg, Germany, in Monaco, and at Sunbury-on-Thames in the United Kingdom. The new factory is located at Lockweiler between Saarbrücken and Trier, and will be known as Saarländische Werkzeug und Maschinenfabrik, Walther Nothelfer G.m.b.H.

ABERDARE HOLDINGS, Ltd., announces the appointment of Mr. Norman Care as general sales manager. He will control the whole of the sales activities, at home and abroad, of the manufacturing companies located in Great Britain which form part of the group. A group sales office has been established at the Blackwood factory of South Wales Switchgear, Ltd., to co-ordinate the outside sales of Aberdare Cables, Ltd., South Wales Switchgear, Ltd., Aberdare Engineering, Ltd., and Neckar Water Softener Company, Ltd. Mr. G. J. Reeves has been appointed industrial sales manager and will co-ordinate all home sales in the industrial field for the group of companies.

THE BRITISH STEEL PILING COMPANY, Ltd., announces the transfer of its plant division from London to Zenith Works, Claydon, near Ipswich (telephone, Claydon 366–8), with effect from Tuesday last. The company wishes to emphasise that the location of its piling division dealing with Frodingham steel sheet piling, box piles, steel trench sheeting and B.S.P. cased piles remains at 10, Haymarket, London, S.W.1. Mr. B. C. A. Cox has been appointed general sales manager of the company and will continue to operate from London. Mr. F. R. Bush has been appointed sales office manager, plant division at Claydon. Mr. D. C. Bean, a director of B.S.P., will also have his office at Claydon from August 15, 1961.

Contracts

A.E.C., Ltd., a company of the A.C.V. Group, has received from Steels Engineering Products, Ltd., of Sunderland, an order amounting to £125,000 for eighty engine and gearbox assemblies of different kinds, auxiliary gearboxes and front axles ; these units will be installed in Coles mobile cranes.

SOUTH DURHAM STEEL AND IRON COMPANY, Ltd., has received the order for the pipe, in equal lengths of 22in, 24in and 26in diameter, for the 30-mile pipeline, of 100,000 barrels per day gravity flow capacity, which the Kuwait Oil Company, Ltd., are to build between the Minagish field and the storage tank farm at Ahmadi.

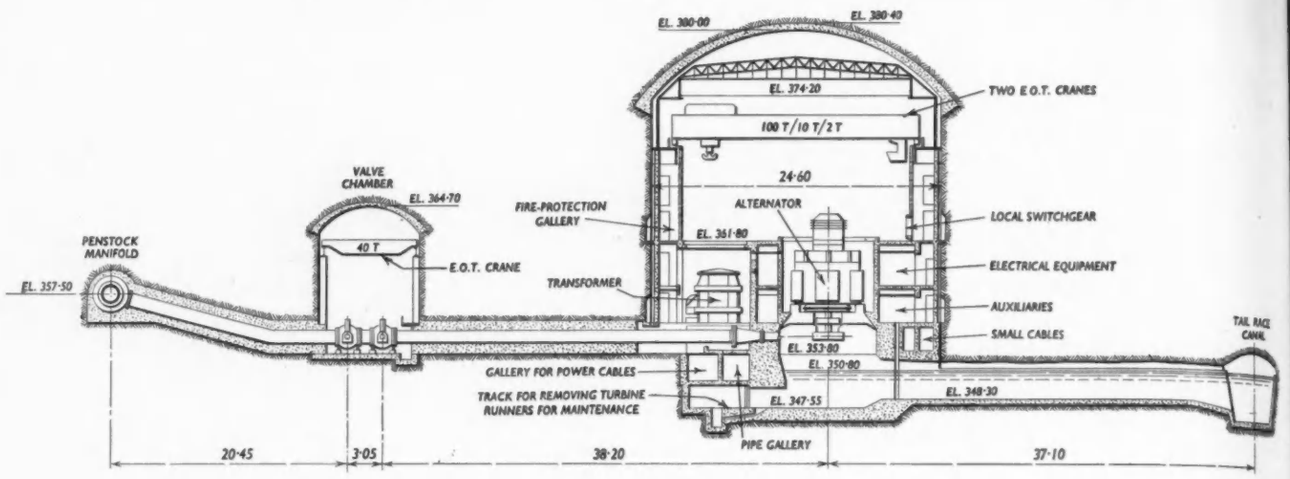
THE GENERAL ELECTRIC COMPANY, Ltd., has been awarded the contract to supply a radio link for Cable and Wireless, Ltd., between the Jamaican terminal of the U.S.A.–Jamaica submarine cable at Seven Mile Point and the Central Telegraph Office in Kingston. The equipment to be supplied operates in the 2000 Mc/s frequency band and is capable of carrying up to 240 speech circuits per radio channel. A main and a standby radio channel will be available. In the event of failure or degradation of the main channel, changeover to standby is automatic.

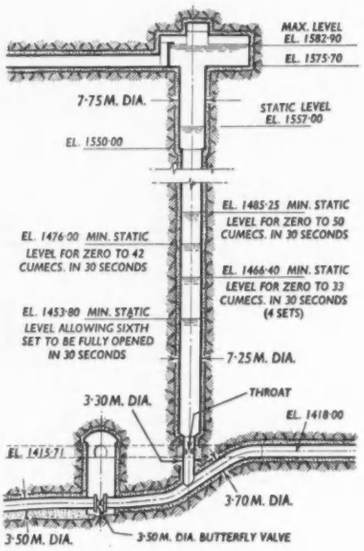
VICKERS-ARMSTRONGS (ENGINEERS), Ltd., has secured a contract valued at over £250,000 for the manufacture, supply and installation of a new rotary kiln to replace a smaller unit which has been in service at the Oxfordshire works of Chinnor Cement and Lime Company, Ltd. for over thirty years. This new kiln, incorporating devices to increase fuel efficiency, will increase the existing capacity of the works at Chinnor by 25 per cent. The engineering work involved will be undertaken essentially by the Barrow-in-Furness works of Vickers-Armstrongs (Engineers), Ltd. It will be recalled that Vickers-Armstrongs completed in 1959 the reconstruction, modernisation and expansion of the Chinnor Works, which was designed to increase their output by 85 per cent.

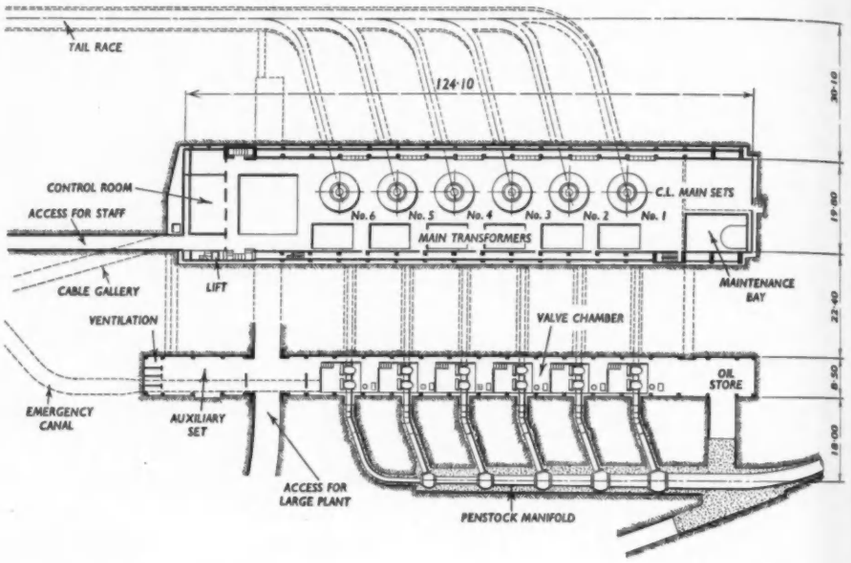
STANDARD TELEPHONES AND CABLES, Ltd., has received a contract worth £2,500,000 from British European Airways for the first stage of an electronic seat-booking system based on two pairs of programme-controlled computers to be installed in the new permanent West London Air Terminal of B.E.A., now under construction. Ultimate cost of the complete system is estimated at £4,500,000. The computer system will handle bookings on all B.E.A. flights up to nine months ahead and store reservations records on magnetic drum and tape files. Reservations clerks will interrogate the computers by means of push-button desk units, and when a booking is made will teleprint details into one of the tape stores. Initially only reservations clerks in the London area will be connected directly to the computing centre, but later it is planned to provide direct connections, over leased landlines, for reservations clerks in other principal B.E.A. offices in the United Kingdom and on the Continent. The first part of the system will be in operation late in 1963, and completion of the scheme is due by the end of 1964.

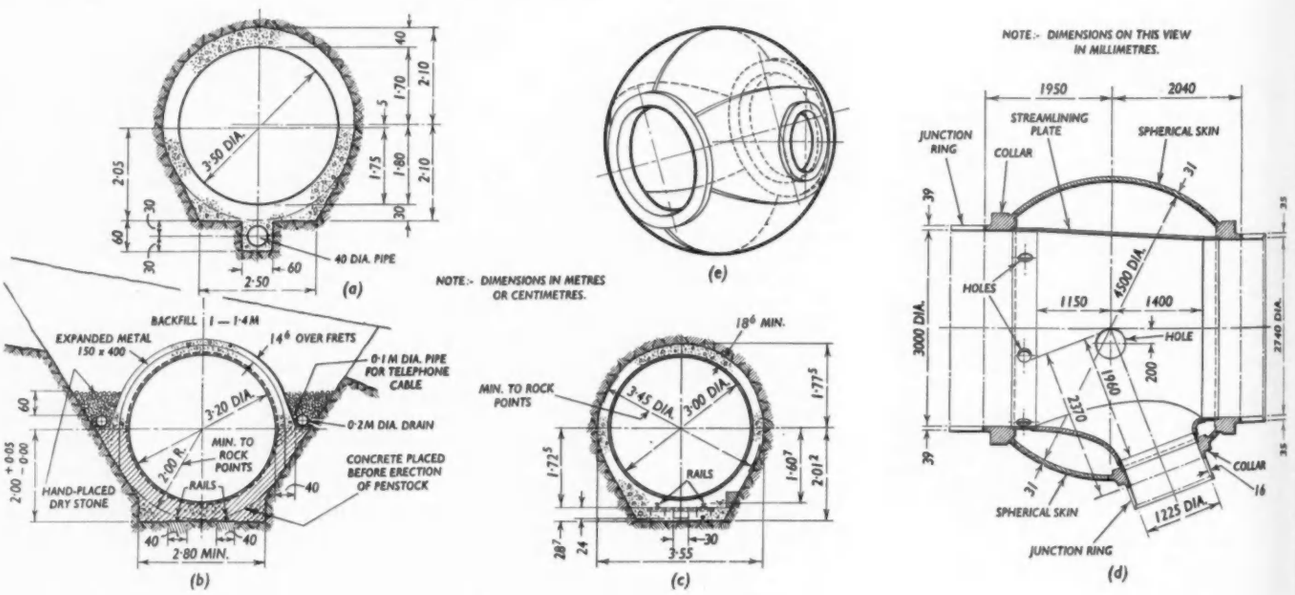
ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., is to supply electrical equipment worth nearly £250,000 for driving four 3000ft per minute, 165in wide tissue machines which are being built, for installation in Russia, by the Walmsley Group. Each section of the machine is driven by a d.c. motor supplied from its own generator, the generator field being excited by the magnetic amplifier output stage of a transistorised regulator which constantly compares motor speeds with a highly stable reference voltage. Electronic control holds the speeds of adjacent sections to an accuracy within $\pm 0 \cdot 1$ per cent, and the overall machine speed to within $0 \cdot 2$ per cent of top speed despite changes of load, ambient temperature or supply system variation. Each of the four drives will have eleven section geared motor drives (totalling 1300 h.p.), five of the eleven being speed regulated and one, on the break-back roll, being torque regulated. In each case the eleven section geared motor drives will be situated with their motor-generator sets and contactors and electronic control equipment in a drive annexe at the back of the machine. The main m.g. set is driven by an 800 h.p. unity power factor synchronous motor and the auxiliary m.g. set by a 325 h.p. induction motor, both supplied from the mill h.t. supply.

UNDERGROUND WORKS OF THE ROSELEND SCHEME




MAX. LEVEL EL. 1582·90
EL. 1575·70
7·75 M. DIA.
STATIC LEVEL EL. 1557·00
EL. 1550·00
EL. 1485·25 MIN. STATIC LEVEL FOR ZERO TO 50 CUMECS. IN 30 SECONDS
EL. 1476·00 MIN. STATIC LEVEL FOR ZERO TO 42 CUMECS. IN 30 SECONDS
EL. 1466·40 MIN. STATIC LEVEL FOR ZERO TO 33 CUMECS. IN 30 SECONDS (4 SETS)
EL. 1453·80 MIN. STATIC LEVEL ALLOWING SIXTH SET TO BE FULLY OPENED IN 30 SECONDS
7·25 M. DIA.
3·30 M. DIA.
THROAT
EL. 1418·00
EL. 1415·71
3·70 M. DIA.
3·50 M. DIA.
3·50 M. DIA. BUTTERFLY VALVE





(*a*) Steel lined tunnel, substantially horizontal from surge shaft to surface.
(*b*) Penstock built in trench.
(*c*) Penstock in rock.
(*d*) Detail of first penstock bifurcation.
(*e*) Fabrication of spherical bifurcation assembly. The dished sections of steel plate forming the sphere are shown as welded together. After bevelling the three circular holes, the three collars are welded on, as they are shown in the sketch.

Top : Typical section through the power station and valve chamber. Centre right : Plan of power station and associated tunnels. Centre left : Section through surge shaft. Bottom : five sketches of penstock construction

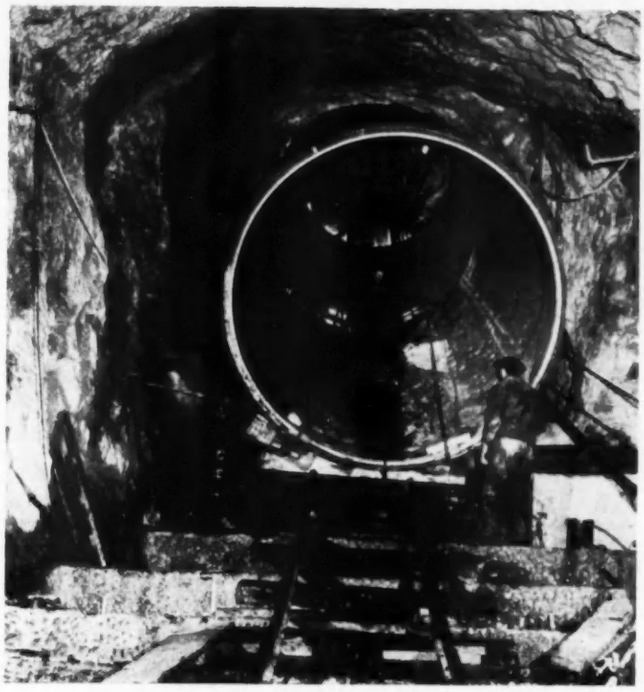
CONTINENTAL AFFAIRS

by Our Continental Editor

Roselend Hydro-Electric Scheme

No. II—(*Continued from page 249, August 11, 1961*)

The general outline of the Roselend hydro-electric scheme, the principal data for the scheme, and a description of its main dam, were given in Part I of this article last week. We continue with notes on other features of the schemes which are of more than usual technical interest, starting with the pressure tunnel. On the right we show construction in progress at the elbow at the bottom of the penstock.



DATA relating to the pressure tunnel were listed in Table I last week, from which it may be recalled that the maximum static head which the tunnel has to withstand is as high as 150m. Economic studies between alternative designs showed that by omitting a "break-pressure" power station (which would have operated in the head range 80m to 210m) a capital sum of 30,000,000 N.F. became available to cover the extra steel lining and strutting necessary for a pressure tunnel, and to cover constructional hazards. The inconvenience of operating two power stations, and the difficulty of storing the flow from those catchments debouching directly into the tunnel, were factors which led to the adoption of the design with only one power station.

For the great majority of its length, the pressure tunnel is in crystalline schist of good quality, and its lining consists of a simple ring of concrete, 20cm to 30cm in thickness to rock points, keyed to the rock by grouting. Construction through this good rock was based on conventional practice, but with the highest possible degree of mechanisation. The concrete lining was not constructed until completion of the excavation.

In places where the rock cover was less than one or one-and-a half times the hydrostatic head, the tunnel has a steel sheet lining of sheet 12mm to 16mm in thickness, stiffened by circular ribs on the outside, so that it can resist hydrostatic pressure outside when the tunnel is empty. A strong steel lining was also utilised in certain places where the rock was poor.

Extensive explorations were carried out before construction of the tunnel to ascertain the nature of the rock through which it was to pass, whether special measures would be necessary in construction, how the lining was to be designed, and how to ensure that the finished tunnel would not leak. In fact it was discovered that the schist was watertight, but that ground water was present up to a pressure of 20kg per square centimetre.

Only in one short length of tunnel known as "l'accident du Chornais" was serious difficulty encountered. Over a length of about 75m, 12m in Carboniferous and 56m in Triassic zones, a region of finely powdered limestone, water-bearing at 19·5kg per square centimetre pressure, was encountered. A watertight "cylinder" of treated ground was created around the position of the tunnel, so that the tunnel could be driven through this zone. This was done in the following manner.

A reinforced concrete wall was built at the end of the tunnel constructed in good rock. Holes were drilled through the wall to form a cone-shaped envelope over a length of 35m, and commanding a cylinder of rock giving at least 5m of "cover" outside the constructional size of the tunnel, i.e. a diameter of 15m. Treatment by (*a*) chemical injection at 70kg per square centimetre giving, after a short time, a gel of silica, and (*b*) cementation at 150kg per square centimetre, was carried out from these holes. The silica gel assists the penetration of the cement grout, in ground where the grout would only penetrate directly with great difficulty; also it augments the cohesion and watertightness of the zone which it treats. Five stages of construction were necessary, viz: (1) systematic primary treatment as just explained; (2) drilling exploratory holes; (3) secondary treatment; (4) excavation and shoring of the tunnel; (5) construction of a preliminary reinforced tunnel lining (the final lining was eventually built inside the preliminary one). A length of 30m of tunnel was constructed in this way, and then the whole cycle was repeated.

The Penstock

At the end of the pressure tunnel is a surge tank, which is throttled where it joins the tunnel, and has an expansion chamber at its top, as shown in the diagram on page 286. There is an underground chamber immediately on the downstream side of the surge tank, containing a butterfly valve which can close off the penstock. From this point there is a single conduit right down to the power station manifold. It consists of the following: continuation of the pressure tunnel, virtually horizontally from the valve chamber as a steel-lined tunnel, until the surface is reached; a penstock on the mountainside, comprising an auto-fretted steel pipe with rigid frets, positioned in a trench, then concreted in and the trench back-filled; lower down, where the duty is severest, underground construction in an inclined tunnel, again with auto-fretted steel, but this time largely comprising two concentric pipes, the whole solidly concreted to the rock whose strength is utilised; and finally the manifold section comprising five successive bifurcations, each comprising a welded-steel spherical assembly again solidly backed to the rock, and providing a branch to each turbine. The principal dimensions and data relating to the penstock are grouped in Table II, and constructional details can be seen in the group of sketches at the foot of page 286, and in the three photographs of the penstock construction which we reproduce.

The first stage of this penstock complex, viz. the steel-lined tunnel, is an orthodox construction for the end of a pressure tunnel. The succeeding stages, however, merit some further explanation. The process known to French engineers as auto-frettage has been employed on many hydro-electric schemes, but its principle is worth describing here, because the evolution of the penstock design associated with this technique has taken an appreciable step forward in the case of the Roselend scheme,* enabling the entire capacity of the scheme to be carried by one conduit—500MW of power, or in other terms, a flow of 50 cumecs under a static head of 1200m. This is considered to be a record performance made possible by various technical

* The design of the Roselend penstock is explained quite fully by M. R. Cartier in *Le Houille Blanche* for January/February, 1960.

CONTINENTAL AFFAIRS *(Continued)*

advances and by the contribution of the rock surrounding the penstock where the head is a maximum, in the lengths adjoining the power station. By comparison, the Malgovert power station nearby is supplied by two penstocks, which were brought into use in 1952, and were then an advance in practice in this field. The capacity, head and flow at Malgovert are respectively 320MW, 750m and 50 cumecs, so that in this case 160MW of power is transmitted by one

Works view of length of conduit for upper section (i.e. section in trench), of penstock awaiting "auto-frettage." The pipe diameter is 3·2m and gap of 32mm between the pipe and the frets can be seen at this stage.

conduit. By achieving a design with only one penstock at Roselend, appreciable savings in costs have resulted.

Auto-frettage as utilised in the upper section of the Roselend penstock consists of placing the steel hoops, or frets as they were termed earlier, round a length of pipe. The pipe is put into a hydraulic press, and a hydraulic pressure is applied inside it; it thus expands, making contact with the frets and putting them in tension. The internal pressure is increased sufficiently to stress the pipe beyond its elastic limit, but the frets must not be stressed beyond their elastic limit. Thus on removal of the internal pressure, the pipe remains in compression and the frets in tension due to the permanent set of the pipe. The advantages of this operation in terms of the working pressure which the pipe can then withstand will be apparent to any student of "prestressing" using that word in its widest sense.

Auto-frettage is limited by the elastic limit of the frets, which must not be exceeded at any stage. The pipe, however, is cold worked by the process, which increases its elastic limit by 5 per cent, producing at the same time an elongation of about 0·5 per cent.

For the pipes lower down the penstock—still referring only to the section on the surface—where the static head is bigger, the process is carried further, and is termed "surpressé à 2 per cent auto-fretté." Some further explanation of this is necessary. The makers distinguish three categories in which the elastic limit is raised viz. (i) "surpressé." A pipe (without frets) is placed, in a mould for example, and elongated. This process, known as "surpressage" increases the elastic limit of the steel plate forming the pipe by 5 to 10 or even 20 per cent; (ii) for a pipe "surpressé auto-fretté" the two processes are employed, but in practice are applied simultaneously, since the "mould" is replaced by the frets. The frets are placed with an initial clearance of 2 to 5 per cent, and the plate of the pipe is thus elongated before coming into contact with the frets; thus the elastic limit of the plate is raised, as in the first case; (iii) "auto-fretté surpressé" In this case the operation of auto-frettage is carried out as normally, the frets being placed in the pipe with an initial clearance of 0·5 to 1·0 per cent, but the whole assembly is "surpressé" till it is held by the interior of a mould. The elastic limit of the frets is therefore also raised.

For the lower section of the Roselend penstock, the pipes have been "surpressé" at 2 per cent before the "auto-frettage" such that the elastic limit is raised by 20 per cent from 34kg to 41kg per square millimetre. Given that the permissible working stress is calculated with respect to the elastic limit, this operation allows it to be increased from 14kg to 16·5kg per square millimetre for a factor of safety of 2·5, or from 16kg to 18·5kg per square millimetre for a factor of safety of 2·2. The saving in weight is thus of the order of 15 per cent for the steel plate of the pipe. It is pointed out to us by the penstock contractor that practically, as the process "auto-frettage" costs the same as the process "surpressage and auto-frettage" there is much interest in this technique; further, the materials and the welds are proved in an outstanding way.

The end result is that adding the outer hoops and applying "auto-frettage" increases the permissible working pressure which the pipe will withstand by 5 per cent. Addition of the "surpressé à 2 per cent auto-fretté" stage gives an additional increase of 20 per cent to the permissible working pressure above the simple "autofrettage" stage.

The length of penstock in tunnel is built following the same principles, entirely to the 2 per cent elongation stage, though in this case the "frets" have been replaced by a complete outer pipe, as we have already mentioned with special steel of high elastic limit. A continuous outer surface was essential to achieve satisfactory grouting to the rock in the tunnel.

The double-walled conduit of 3·0m diameter of the lower section of the penstock. Again this view is before works processing, and there is a gap of 30mm between the two walls at this stage.

Only the interior pipe is welded at the joints, however, the lengths of interior and exterior pipes being respectively 2·75m and 2·69m. Pairs of them were welded in the shop, and the remaining joints welded *in situ*.

Design principles for auto-fretted penstocks are based on an elastic limit/strength ratio, works tests to double the working pressure (yet still below the elastic limit) being preferred. The upper (surface) length of penstock has a factor of safety of 2·2 in relation to maximum working pressure and the elastic limit for hoop stress. The surrounding concrete resists collapse due to low pressure (1kg per square centimetre) inside the pipe with a factor of safety of 2.

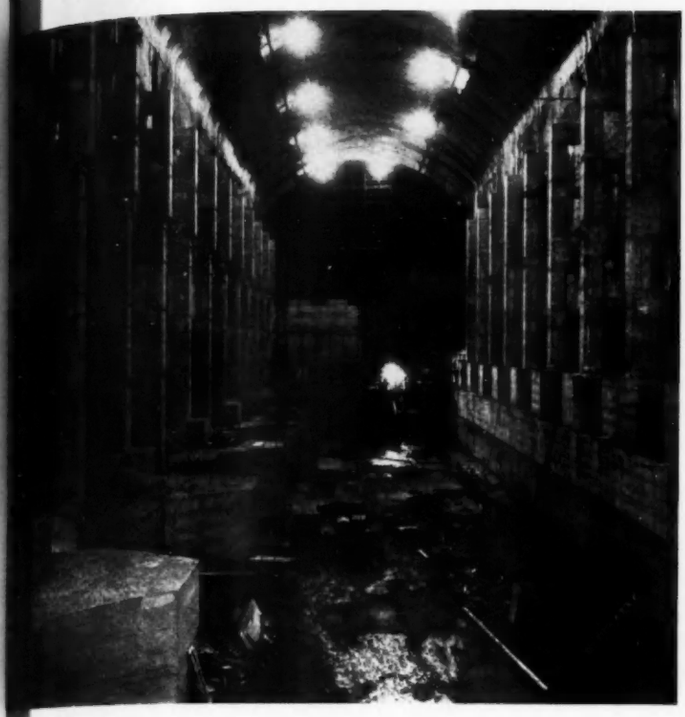
For the length in tunnel, the same factor of safety of 2·2 is retained until a good cover of rock is reached, but it is then reduced progressively to a figure of 1·4. This factor of safety of 1·4 does not take account, however, of the strength of the rock. Since this construction still comprises a pipe with rigid frets, grouting of the steel to the concrete backing was not envisaged, though the surrounding rock was treated with grout.

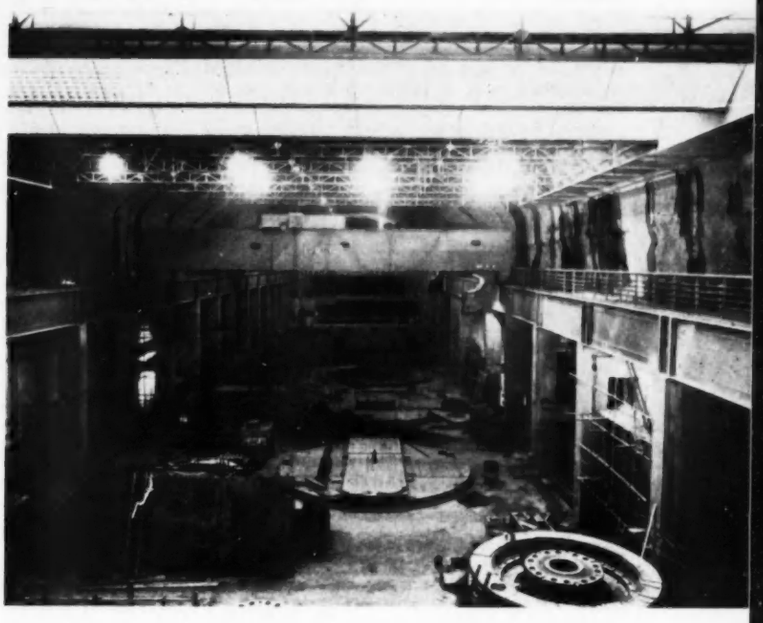
About 350m from the start of the lower section, the double-walled, grouted, construction commenced. At this point the factor of safety, as defined above and corresponding to the elastic limit of the steel, was again reduced, this time to a value of 1. The design thus ensures that the steel will work within the elastic limit if there is no additional support from the rock, but in fact the support given by the rock raises the effective modulus and the steel works at lower duty. A second design criterion was that

TABLE II—*The Penstock*

Main features :	
Maximum gross head	1203m
Maximum discharge	50 cumecs
Capacity	500MW
Length (without manifold)	2430m
Diameter	3·50m to 3·00m
Approximate weight of steel (without manifold)	8000 tons
Dimensions :	
Steel-lined tunnel from surge shaft to surface :	
Length	462m
Diameter	3·5m
Slope	0·9 per cent
Tunnel invert level (downstream)	1393·6m
Maximum static level in surge shaft	1557·0m
Upper section of penstock built in trench on the mountainside :	
Length	1150m
Mean slope	54 per cent
Diameter	3·2m
Lowest level of this section	842·5m
Lower section of penstock built in tunnel and structurally utilising the surrounding rock :	
Length	850m
Diameter	3m
Slope	69 per cent
Level at which penstock goes into tunnel	842·5m
Level of turbine jets	353·8m
Maximum rock cover	220m
Tyres and properties of steel :	
Note : 1kg per square millimetre = 1422·3 lb per square inch	
Steel lining of tunnel :	
Type of steel	Martin A55M
U.t.s.	54kg per square millimetre
Elastic limit	36kg per square millimetre
Elongation	20 per cent
Thickness of steel	16mm to 24mm
Penstock in Trench :	
Type of steel for pipe	Confor "E," copper-chrome semi-rustless C.F.36
U.t.s.	52kg per square millimetre
Elastic limit	36kg per square millimetre
Elongation	20 per cent
Pipe thickness	17mm to 32mm
Type of steel for frets	"Martin supérieur"
U.t.s.	100kg per square millimetre
Elastic limit	70kg per square millimetre
Elongation	8 per cent
Dimensions of frets	100m by 27mm and 100mm by 54mm
Penstock in Tunnel :	
Top 350m :	
Type of steel	CF36 as for preceding section
Pipe thicknesses	32mm to 21mm
Frets	100mm by 64mm and 100mm by 46mm
Lower 500m :	
Steel of inner wall	CF36 as preceding section
Steel of outer wall	Super Elso 1·5 DFON (Schneider)
U.t.s.	85kg per square millimetre
Elastic limit	68kg per square millimetre
Elongation	10 per cent
Thickness of internal wall	18mm to 26mm
Thickness of external wall	17mm
Manifold :	
Type of steel	Elso 38 (Schneider) CF 36
U.t.s.	52kg per square millimetre
Elastic limit	36kg per square millimetre
Elongation	20 per cent
Thickness of pipe	34mm to 16mm
Frets	100mm by 63mm and 90mm by 18mm
Maximum auto-frettage pressure :	
Penstock	187kg per square centimetre
Manifold	310kg per square centimetre

Note : CF36—"Conduites Forcées 36 kg per square millimetre," European standards for penstock construction.





La Bathis power station under construction. (Left) The machine hall excavation with columns for e.o.t. cranes constructed. (Right) A later stage showing installation of the main plant; in foreground, the first section of saw-toothed translucent ceiling

external pressures on the empty penstock must also be resisted within the limits of elastic working, for this calculation a head 10m greater than the vertical rock cover being assumed. In the manifold section the corresponding figure for factor of safety was increased to 1·5 and to 2·5 in the region of the valve chamber.

The five bifurcations of the manifold each presented an interesting problem in design and manufacture. The first (i.e. largest) is shown in cross-section ; it comprises three laminated steel collars mounted in a sphere of steel plate, with junction rings to connect with the three penstock pipes, and sheet steel linings to streamline the interior, these latter being of different steel from the rest of the construction. An all-welded method of assembly was employed, as indicated in outline by one of the sketches on page 286. The completed bifurcations were tested to a pressure of 138·4kg per square centimetre. A working stress of 54kg per square millimetre (i.e. 80 per cent of the elastic limit) was allowed in design.

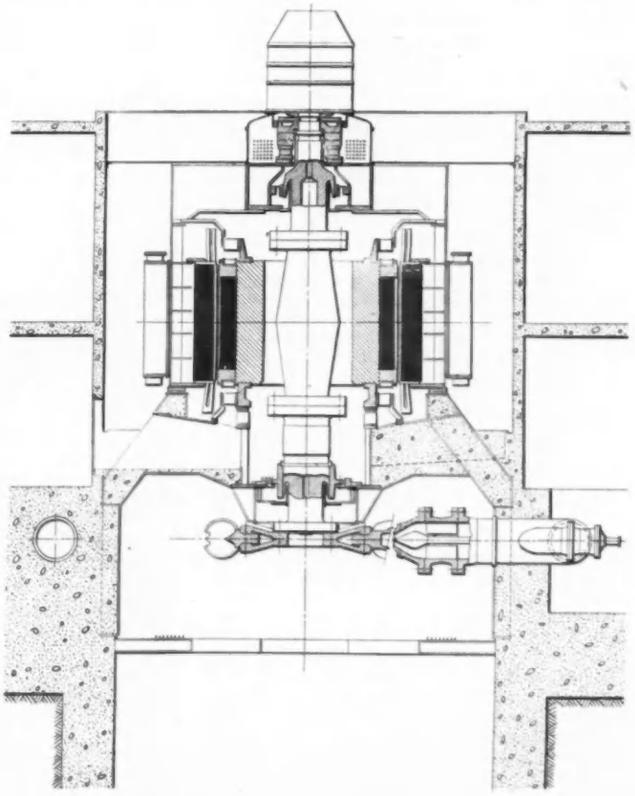
Corrosion protection is always an important yet costly problem for a big penstock. At Roselend the calculated thicknesses of steel were increased by 2mm for thicknesses of 10mm and less, and by 1mm for thicknesses of 11mm to 20mm, to allow for corrosion. Exterior steel surfaces received, in general, no treatment when they were solidly connected to concrete. Otherwise, sand blasting, plus three coats of paint, sufficed. Treatment of the interior of the penstock, however, was quite different. First the whole interior surface was sand blasted, then the surfaces of the welds at the joints were ground smooth. Then a coat of hot smoothed enamel with a minimum thickness of 1·5mm was applied. The grinding and enamelling reduced the loss of head in the penstock by 6·25m (from 23·65m to 17·4m) it was considered. The capitalised value of 1m loss of head was computed to be 500,000 N.F.; the extra cost of grinding and enamelling was 180,000 N.F.

The Power Station

Design of the penstock (as described above) and the power station took advantage of the sound rock forming the lower part of the mountainside at La Bathie. The length of penstock in trench passes over a zone of poor rock, but a crystalline schist of uniformly good quality was known to be present for the underground section of the scheme, i.e. the lower part of the penstock, the power house and that section of the tail race which is in tunnel. These rock conditions had been ascertained from extensive exploratory work.

An underground power house was complementary to the penstock design. Its advantages were : (*a*) the penstock was then as short as possible. A surface power station would have needed a further 300m of penstock, and hence a loss of 3m of head (the monetary penalty of losing 1m of head is quoted in the previous section of this article) ; (*b*) a surface design would have required two conduits, with about 2000 tonnes more steel. These advantages outweighed the extra cost of excavation. The centre line of the power house was aligned perpendicular to the strike of the rock without complicating the layout of the conduits, and the poor foundation conditions with which a surface power house would have been confronted were avoided. An alternative design for a vertical or steeply sloping shaft leaving the surge shaft, and connected by a horizontal tunnel to the power house, was discarded because of the bad rock in the upper zone.

Having thus established the desirability of an underground design, further design studies aimed at minimising the excavation needed for it. First of all, it was considered desirable to group all the main plant under a single overhead crane within one chamber, but it later became apparent that vertical-shaft sets, with a separate valve-chamber, gave the best solution. The layout thus resolved itself into six Pelton-wheel-driven sets in the principal chamber, each as illustrated in the cross-sectional view herewith, and each with a high-tension transformer placed beside it. The underground works consisted of



Cross section of vertical-shaft, Pelton-wheel turbo-alternator of 82·7 MW. Six of these sets are installed at La Bathie.

CONTINENTAL AFFAIRS *(Continued)*

four parallel excavations, viz : (1) the manifold section of the penstock ; (2) the valve chamber, commanded by a 40-tonne crane and containing two spherical valves in series on each of the conduits feeding the six turbines ; (3) the power station itself ; and (4) the tail race tunnel. In addition to these four, and of course, to the cross tunnels to and from each turbine, there is (*a*) an emergency tunnel connecting the valve chamber with the tail race ; (*b*) access tunnels for plant and staff respectively ; (*c*) an emergency access tunnel for staff at a higher level ; and (*d*) a tunnel containing the high tension cables.

The reasons why a vertical shaft arrangement was favoured for the main sets are of interest ; they hinge on a better utilisation of space, and hence reduction in volume. Thus the two separate "circuits," i.e. of water and of electrical energy, are virtually separated and take place at lower and higher levels respectively. Reduction in the size of the main sets was also possible, by an increase in specific speed. An operational speed of about 375 r.p.m. was imposed by current practice, but it was considered reasonable to increase this to 428 r.p.m. It was thus possible to build the stators in the maker's works, and transport them in one piece, already wound, to the site. Dismantling an alternator was also considered simpler with a vertical shaft. Further, a novel method of dismantling the turbines permitted a reduction in headroom of 2·5m. Each set has a hollow shaft. The tail bay of any set can be isolated and dewatered by stoplogs. A trolley can then be run, on rails, to a position immediately below the turbine. The runner can then be lowered, without moving the alternator, by the overhead crane, on to the trolley, which is then moved to a special bay, also commanded by the overhead crane, where it can be lifted to the main hall.

Placing the transformers directly beside the generating sets is also an unusual point, which has led to reduced cubic content. Each transformer is enclosed by reinforced concrete walls, which can withstand a pressure of 1200kg per square centimetre inside the transformer cell, should the transformer catch fire. Oil-filled cables connect the transformers with the switching station on the surface. The distance between centre lines of the main sets is about 12·5m ; a distance of about 18m would have been needed for horizontal-shaft sets, it is considered, and the head-room would have been about the same.

Considered overall, an exceptionally clean design has been achieved in the appearance of the power station. Prefabrication was resorted to extensively during construction so that everywhere site work was reduced to a minimum, both for the plant and the structure. The arch of the machine hall is not visible, a ceiling of saw-toothed shape having been constructed below it. This shape reduces noise (also the transformers are on rubber mountings) and accommodates concealed fluorescent lighting. Also false walls separate the rock from the machine room. Air conditioning is comprehensive and is expected, paradoxically, to involve warming in summer and cooling in winter, since the sets will not operate very much in the summer. The valve chamber also accommodates an auxiliary Pelton-wheel-driven generating set, cooling water pumps, oil storage, and ventilating and air conditioning plant.

Catchwater Systems

Part of the extensive system of catchwater aqueducts feeding into Roselend reservoir remains to be constructed. Future work includes Gittaz reservoir and les Sauces power station. Both Gittaz and St. Guérin are quite sizeable arch dams, but are conventional in comparison with Roselend dam, so they have not been described here. Similarly the catchwater system, like all Alpine systems of this kind, entailed difficult problems of access, and of working at high altitudes. It includes one major siphon ; numerical data for this siphon and for the system generally were given in Table I *ante*.

St. Guérin reservoir is hydraulically connected with the main reservoir, so the two are always at the same level. Intakes on the main catchwater system were designed to exclude sand and boulders from the diverted water, a simple automatic system for flushing out the solid materials accumulating at an intake being utilised. For those intakes discharging into the pressure tunnel, air also has to be excluded. In one case a siphonic intake and shaft leading to a chamber beside the pressure tunnel was constructed for this purpose.

Cost

Our description has emphasised somewhat the economics sought by advanced design. The overall cost of the scheme is thus of direct interest. The following figures have been published : on the basis of 1957 prices, total cost of the scheme slightly over 50×10^9 francs (i.e. 50×10^7 N.F. or about £72 per kilowatt) ; comparable cost for a modern coal-fired power station of four 125MW sets, about 30×10^9 francs ; additional annual charge for the 300,000 tonnes of coal consumed by the latter, at least 2×10^9 francs, i.e. at least 10 per cent of the additional capital cost of the hydro-electric scheme.

After several years of exploratory work, construction of the Roseland scheme started in 1955. Excavation for the foundations of the dam started in 1956, and concreting in 1957. The first stage of filling the reservoir—up to the 1520m level—occurred last summer and the first set in the power house was commissioned by December 10 last. The sixth set was commissioned on March 17, and by April 7, 200 million units had been generated at La Bathie.

Harbour Cranes for Hamburg

Twenty-four dockside cranes of the design shown in the accompanying illustration are being installed in Hamburg. The cranes, built by Krupp-Ardelt G.m.b.H., Wilhelmshaven, have a capacity of 3 tonnes at radii ranging from 7m to 25m, with level-luffing at up to 25m above rail level. The portal runs on a rail track of 6m gauge (measured between rail centres). Loads can be hoisted at 40m per minute, slewed, at maximum radius, at 2 r.p.m., and level-luffed at 63m per minute. The crane can travel at 20m per minute.

The design is claimed to be such as to eliminate water and dirt pockets. The jib telescopic screw spindle has been brought forward so as to limit the amount by which it protrudes to the rear. This lessens the risks of collision with other cranes or with parts of the ship's superstructure. An additional control permits the normal height to be exceeded at minimum radius so as to give a maximum lifting height of 36m.

European Computer Manufacturers' Association

The establishment has been announced of a European Computer Manufacturers' Association (E.C.M.A.) with headquarters and secretariat in Geneva. Members of the Association are companies in Europe which develop, manufacture and market data processing machines designed to process digital data for business, engineering, scientific and other similar purposes.

The object of the Association is to further the adoption of data processing standards for the benefit of users, the public and the industry itself. Its primary purpose, in co-operation with national and international standards organisations, is to secure inter-company co-operation throughout the industry regarding the establishment of systems and equipment compatibility, the development of common systems languages and in other appropriate fields of activity.

Natural Gas in Israel

A 6in pipeline 29km long has been completed, bringing natural gas from the Rosh Zohar deposits to the Dead Sea potash works at Sodom. The gas is stated to consist of 97·5 per cent methane and 2·5 per cent ethane. Fuel costs will be cut drastically, as 130,000 tons of gas are to be piped in over the next three years, and 100,000 tons annually over the eight following years, in co-ordination with the Dead Sea Works expansion programme. Further pipelines are intended to distribute gas to the Oron phosphate works, the textile plants at Dimona, the atomic reactor and to a new petro-chemical industrial centre at Arad, where plastic materials, synthetic fibres, artificial fertilisers and synthetic rubber are to be manufactured.

Level-luffing 3-ton cranes at Hamburg

THE AMERICAN SCENE

By Our American Editor

Large-Capacity Document Storage and Retrieval System

THE International Business Machines Corporation, of New York, has developed a new electronic system that is able to retrieve any one of millions of printed or typed pages or photographs from a file centre within five seconds. A small image of the document is photographically transferred to an I.B.M. punched card so that the document can be viewed on a screen or printed out without removing it from storage. The so-called "Walnut" prototype information system was developed by the Advanced Systems Development Division of the firm for the Central Intelligence Agency of the U.S. Government. It represents an important step forward in current efforts to create new technology to help government, industry and institutions cope with the mounting volume of documents resulting from new knowledge and information in many fields. Such a system can store millions of periodicals, engineering drawings, legal documents, photographs, patent records, and similar information.

The operation of "Walnut" is comparable to that of a library—a dynamic type of library serving users almost instantaneously with information. Its catalogue, or index, is a magnetic file. Its "shelves" are bins, each automatically loaded with photographic images of documents that have been reduced to about 1/1000th of their original area. The documents go through two stages of size reduction when they are prepared for entry into the system. In the first instance, they are micro-filmed. The 35mm micro-film is placed in an image converter, which further reduces the image optically and transfers it to strips of film, with each strip containing ninety-nine images. As an image is transferred from micro-film to film strip, control cards are automatically punched to record its location in the file. Since the original film image never leaves the document file, there is no possibility of misfiling or removal of documents from the file. Each bin, or document file, contains 200 plastic cells of fifty film strips each, or a total of 990,000 images. This is roughly equivalent to about 3000 average-size books. The total system can accommodate more than 100 document files.

A user starts his search for information by writing key search words on a form—words such as "Smith," "computer," or "creativity." Punched paper tape made from the form is placed in the machine, and a magnetic index is searched electronically. A list of index entries corresponding to the documents found by the key words is printed and returned to the user. The user checks his choices on the list. Punched cards corresponding to the selected documents are pulled from a file of cards prepared when the document or abstract list was printed. From this file, pertinent data such as image location of the desired document and an identification of the user are automatically punched in an aperture card containing a blank film insert. The unexposed aperture cards are inserted into the document file which reads the location from the punched holes and brings the film strip containing the document image into lens position. The card film insert with up to four images is automatically exposed by ultra-violet light and developed immediately by a dry heat process in about half a second for each operation. The card is then returned to the user, who may enlarge the images to original document size for printing or for viewing with a projection device.

Immediate access to any of the images stored in the bins is faster than locating information which must be searched serially, or by conventional "look up and thumb through" techniques. In these common techniques, the storage medium—whether magnetic tape of cards—must be scanned in sequence, one record at a time, until the desired information is found. The random access procedure of the new system wastes no time with such searching. Information from the magnetic index immediately pinpoints the location of the image in the file so that within seconds the document is ready for viewing or photographic reproduction.

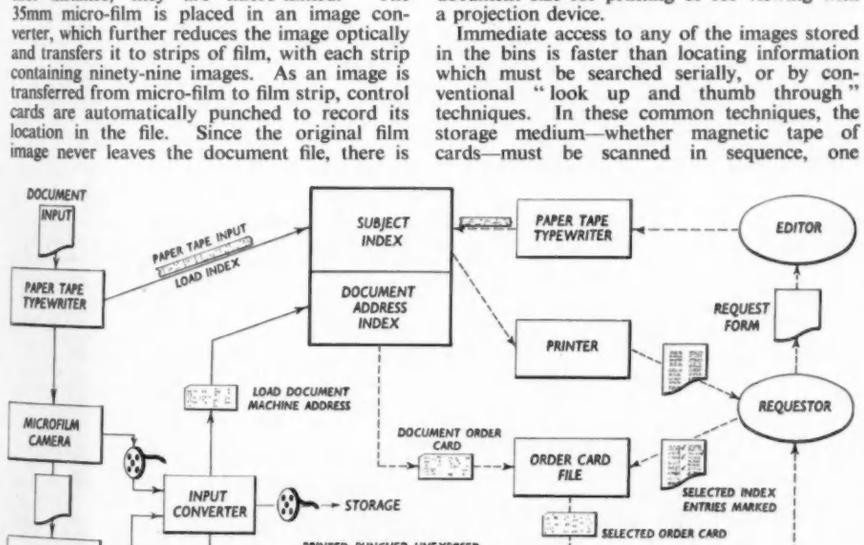


Fig. 1—Diagram of "Walnut" large capacity document storing and retrieval system

System Design

The system consists basically of a document input converter, a document index and a document image file. Both the indexing and the document locating techniques are adaptations of the principle of the I.B.M. "RAMAC" (Random Access Method of Accounting and Control) computer. This feature of the system eliminates time-consuming and costly serial searching for documents. "Walnut" is claimed to be the fastest and most nearly automatic information system developed to date for image storage and retrieval using a large file.

The document image converter optically reduces and transfers conventional perforated 35mm microfilm images of documents intended for the system to film strips for ultimate storage in the image file. The image converter simultaneously assigns image file addresses and punches these addresses into punched cards controlling the conversion process. The address information on the control card is then entered into a portion of the index. By the time the document enters the file, the original has twice been regenerated photographically and has been reduced to less than 1/1000th of its original area.

The large-capacity files of random access photo document, or document image, are the heart of the system. They provide for reproducing any desired document in as little as five seconds. Selected images are projected on to I.B.M. photo aperture punched cards. The film insert of the card contains a film emulsion which, like the film strip, is sensitive only to ultra-violet rays and which is heat-developed without wet chemicals. Each aperture card has space for four images. Following exposure and rapid development, the images may be enlarged to original document size for printing or for viewing with a projection device. The design of both the image file and the magnetic index is modular. Each module of the document image file stores 990,000 pages. New modules may be added without component modification to provide capacities in excess of 100 million document pages and 3000 million characters of coded magnetic index information. The film in the image file is contained in 200 independent, easily removable cells of 4950 pages each. Thus, blocks of inactive documents can make way for active documents while remaining convenient for possible later use.

An associated random access memory is the index to the photo document file. This high-speed, high-capacity coded magnetic file provides great flexibility in recording or searching records of documents in one to two seconds. The index is continuously updated, and it provides bibliographical and punched adress-card output. The latter is used to address the document file. The index performs as part of an integrated system with the input converter and document file, but it can also operate independently in both a physical and logical sense. This makes possible reorganisation, updating and purging of sections of the index without affecting the image file and unlimited cross indexing.

The numerous photographic transfers which take place within the system require accurate mechanical positioning of each image in the optical path of the various lenses. Particularly in the document file, this requires precise

THE AMERICAN SCENE *(Continued)*

rotational and linear movement in locating and projecting a given cell strip and image. Each strip is raised from its normal position in the cell to the projection lens by a fast and accurate tweezer-like device.

System Operation

For each incoming document : (1) a unique document number is assigned ; (2) the page count is recorded ; (3) an index record, including an abstract, is punched to paper tape ; (4) a microfilm image is made ; and (5) an input control card is punched with the document number and page count. The original document is then forwarded to its intended recipient, who may destroy it after it has served its initial purpose. The paper-tape index data is loaded into the magnetic index according to pre-defined subject or keyword headings. The subject groups are alphabetically ordered, as in the card catalogues of conventional libraries. Since the index can search 1000 records, averaging 250 characters in length, in two seconds, the records in any subject group can be stored sequentially as received without further ordering.

The microfilm and the punched input control card are verified for quality and loaded in the image converter, where images on the microfilm reels undergo further reduction and transfer to the film strips that constitute the storage medium of the image file. The image converter automatically assigns the file address to each document in the image cell and each cell in the image file, and punches this address in the input control card. All information in the input control card is recorded in document-number sequence in the document address section of the index. Each image cell, when filled to capacity, is inserted in its assigned location in the image file.

A user fills out a search form with as much information as can be specified. This form is similar in format to the index record. The search criteria are read into registers of a processing unit and cause a search to be made of the subject sections of the index containing records for the specified key words. All records matching the input criteria are printed out at the same time that the document address section of the index causes an address card to be punched. The user reviews all index records emitted and marks the documents he wishes reproduced. These cards are then inserted in an I.B.M. 528 Punched Card Reproducer which punches addresses, page counts, document numbers, and user numbers in photo aperture cards.

When a photo aperture card is inserted into the file, the punched data initiates a sequence of machine operations that culminates in the transfer of the requested document images to the card. Trailer cards are automatically produced when the document length exceeds the capacity of a single photo aperture card. The image-bearing photo aperture card is sent to the user. The card may be studied with the aid of a specially designed viewer or reproduced full-sized by a printer. If copies are needed for a high percentage of index matches, it is possible to modify the system by coupling the index directly to the image file to avoid the delays attendant on manual transfer of index output to image files. In this case, the aperture card would be both punched and exposed in the image file.

Image File

Each module of the image file contains a total of 990,000 images. An image file module about the size of a desk has a capacity equivalent to that of 100 filing cabinets. Each file module holds 200 cell : each cell contains fifty strips. Each strip has a capacity of ninety-nine images of 8in by 14in pages, stored at reduction of thirty-five diameters on film strips. The images on the film strip are in three rows of thirty-three images per column. High resolution film of 550 lines per millimetre is used in the file. It is exposed by ultra-violet light and developed by heat, permitting on-line dry processing in lighted rooms. A somewhat lower resolution film is used as the insert material in the photo aperture card.

The 200 cells of the image file are arranged in a circular bin which is simultaneously rotated and translated to position a specified cell beneath an access mechanism. Image reproduction begins when the document address and page count information in the unexposed aperture card are read in the card feeding mechanism of the document machine. An address consists of the file-module, cell, strip and strip-position numbers of the first page of a given document and page count. When the address on the aperture card has been read and the required cell is brought under the pickup mechanism by a minimum rotation and translation of the bin, the bin is locked by a detent. A caging mechanism then aligns the cell as required by the pickup mechanism. This tweezer-like device has moved, meanwhile, to the appropriate one of fifty strip positions at the same time that the optical system has shifted to the appropriate one of three image columns.

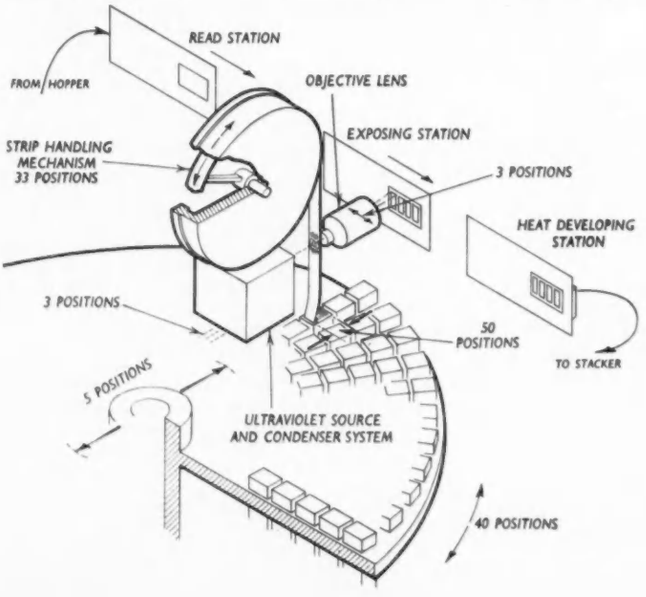
The strip is drawn from its cell far enough to bring each desired image in turn into the optical path. Because the strips are drawn up in grooves dimensionally identical to those in the cell, support is maintained constantly along the entire edge of the strip. The bin remains locked in position, preventing relative motion between grooves in the cell and grooves in the picking mechanism until the strip has been returned to the cell. The safety of the file film is further ensured by a photo-cell, which scans the top of the cell to determine that all strips are properly in place before the detent is released. A high-pressure, 200W mercury arc lamp furnishes ultra-violet energy to expose the images. The photo aperture card has positions for four images, reduced 27·2 times from the original document. All four image positions are heat-developed simultaneously at the stacking station of the card transport mechanism. The throughput of each image file is 500 cards per hour minimum, 600 per hour average.

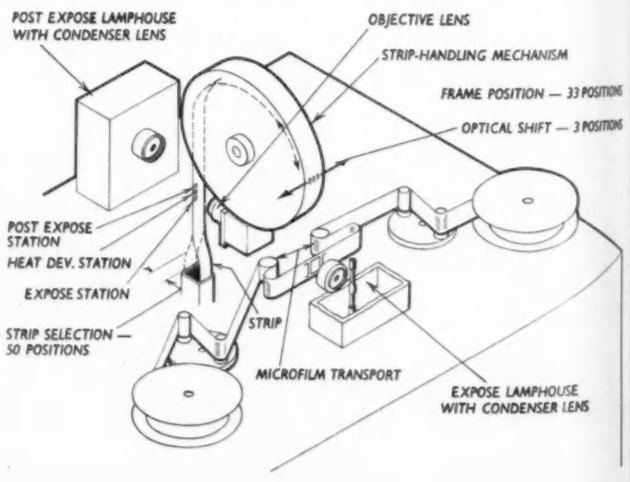
Image file modules may be added without limit. However, to minimise the number of modules required, all cells are removable and each image file has a single-cell mode of operation. Thus cells containing inactive or semi-active documents may be removed from the mechanised file for shelf storage.

Image Converter

The function of the image converter is to transfer document images to the image-file film strips, to assign image-file addresses, and to punch these addresses into the input control card. The image converter is an unattended machine, requiring only initial registration of the microfilm reel and deck of corresponding control cards. The input to the converter is silver halide perforated microfilm. When the microfilm images have been transferred to the file film strips, the reel may become part of a vital record archive. The image converter accepts (1) one reel of developed microfilm images ; (2) the associated input control cards (which were punched with the document number and the page count at the time of microfilming) ; and (3) one image file cell containing pre-loaded unexposed film. The machine operator need only determine that the first input control card and microfilm image corresponds ; from this point on the machine runs unattended until the reel of microfilm has been completely reproduced on the file strips.

A film strip pickup mechanism identical to that on the image file controls film strip positioning. A document may continue from column to column on a strip, or from strip to strip on a cell, but not from cell to cell. The throughput of the image converter is 1500 frames per hour, permitting a cell to be filled in about three hours.





(Left)—Fig. 2—Diagram of image file, showing bin, cell, access mechanism, ultra violet optical system and photo aperture card. (Below)—Fig. 3—Diagram of image converter, showing microfilm drive mechanism, strip selection and pickup mechanism, optical system and film strip

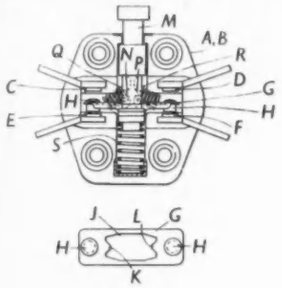
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

873,761. November 20, 1958.—SNAP ACTION ELECTRIC SWITCHES, Brookhurst Switchgear, Ltd., Northgate Works, Chester. (*Inventor : Leslie Brock.*)

One object of the present invention is to provide a simple and robust form of snap action switch particularly suitable for use as an auxiliary switch in electric contactor gear and the like and as a limit switch in machine tools. In the embodiment illustrated the switch comprises two identical half mouldings *A* and *B* between which the working parts of the switch and the fixed contacts are sandwiched. There are two pairs of fixed contacts, *C*, *D* and *E*, *F* respectively adapted to be bridged by the movable contact member *G*. Member *G* is in the form of a plate (lower drawing) provided at its ends with silver contacts *H* which are riveted in position. The contact plate is formed with a central aperture *J* shaped so as to provide oppositely disposed pips or lugs *K* and *L*. The operating bar or push-button *M* for the switch is made of nylon and is slidably supported between the two parts of the switch body which are secured

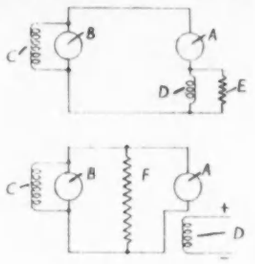


No. 873,761

together by nuts and bolts. The push-button or bar is formed with pips or lugs as indicated at *N* and *P*. Compressed between and supported by the lugs *K* and *L* and the pips *N* and *P* are spiral compression springs *Q* and *R* which, in effect, constitute resilient parts of an over-centre or toggle mechanism. When the push-button is pressed inwardly the inner ends of the compression springs are caused to pass through a dead-centre position relatively to the lugs *K* and *L* and then react to snap the movable contact member from engagement with the contacts *E*, *F* into engagement with the contacts *C*, *D*. In some cases one pair of fixed contacts may be replaced by stops. A spring *S* may be provided which acts on the push-button so that when it is released the contact member will spring back into the position shown in the drawing.—*July* 26, 1961.

873,050. October 15, 1958.—CONTROL EQUIPMENT OF ELECTRIC HOISTING MOTORS, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1, and Steels Engineering Products, Ltd., Crown Works, Pallion, Sunderland, County Durham. (*Inventor : Bernard Henry Stockman.*)

This invention relates to hoisting units of the kind having a d.c. hoist motor supplied from a generator which is driven by a prime mover. Such units are commonly used on mobile cranes, the prime mover being usually an internal combustion engine. The invention aims at providing an improved control arrangement which makes it possible to control load lowering movements by varying the prime mover speed using conventional means, such as a throttle device, and eliminates undesirable effects upon the friction surfaces of brakes in the hoisting gear. The diagrams show one embodiment of the system in principle. A d.c. hoisting motor *A* is supplied from a generator *B* which has a self-excited field winding *C*. The motor has a field winding *D* connected in series for hoisting (upper drawing), and to an external source, such as a battery, for lowering. Where this winding has a low resistance to operate at a low voltage, such as supplied from a battery, during lowering a resistor *E* is connected in parallel to it when it operates as a series field winding, thereby to limit the current traversing the winding when it is connected in series with the armature of the motor during hoisting. A load resistor *F* is provided for connection across the motor during lowering. The hoisting operation with an arrangement according to the upper drawing is conventional and need not be explained. During lowering operation when the circuit connection is as illustrated in the lower drawing the current traversing the motor armature is proportional to the load. If it be assumed



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for the sake of simplicity that the generator is disconnected, all the current generated in the motor armature flows through the resistor *F*, thereby producing a braking effect. The speed of the load at the hook can then be determined by suitable choice of the ohmic value of the resistor. In practice the dynamo-electric machine *B* is always in circuit and its operation is of a generating or braking nature depending upon the relationship between the voltages appearing across the terminals of *B* and *A*. It will be understood that at low speeds of the prime mover and generator the voltage across the generator can be so low that the generator acts as a dynamic load on the motor, which is now generating, and thus the load on the resistor *F* can be relieved by *B*. If the speed of the prime mover is increased the dynamic load on the generator is first reduced and finally at a predetermined speed the effect of the machine *B* will change from dynamic braking to generating. In this manner the speed of the motor and hoisting gear can be controlled directly by varying the speed of the prime mover. In a preferred embodiment described in the specification, the motor has a series field winding and a separately-excited field winding arranged for mutually aiding both during hoisting and braking.—*July* 19, 1961.

ELECTRONICS

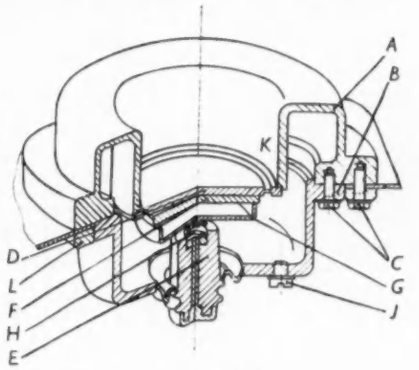
873,321. December 5, 1958.—SIMULATED FLIGHT DISPLAY, Minister of Aviation, London, and Bush and Rank Cintel, Ltd., formerly Rank Cintel, Ltd., 11, Belgrave Road, London, S.W.1. (*Inventors : Donald Clive Bowles and John Michael Naish.*)

It has previously been proposed to produce simulated flight displays by the use of apparatus including moving elements of which an image is transmitted by television techniques. Such an arrangement suffers from inflexibility due to the necessarily permanent nature of the basic elements of the display and also presents difficulties when it is desired to add to such a display additional information such as the position of fixed or moving objects or the desired or actual course of the aircraft. The present invention seeks to overcome the difficulties and disadvantages mentioned above by providing a simulated flight display in which all elements are generated by electronic means as signals which are applied to control the movement and intensity of the electron beam of a cathode ray tube. According to the invention, control signals are generated which develop in the cathode ray tube screen a horizon line of which the position and attitude represent the elevation and bank of the aircraft, while a second set of repetitive signals develop a series of track lines which by their length and positions in the display suggest the altitude and heading error of the aircraft, and which vary from one repetition of the display to the next so as to suggest the speed of the aircraft relative to the earth or another body. The specification describes how a timing device causes control signals to be developed alternately, one displaying a line extending transversely across the display, while the second causes the tube to display a series of lines parallel to the first but of lengths increasing progressively with their distance from that line. The two displays are cyclically repetitive and the lines produced by the second set of control signals are arranged to be displaced at each repetition of the cycle in a manner such as to produce the illusion of an infinite succession of lines moving from a point on the horizon line towards the observer at a speed bearing some fixed relation to the speed of the aircraft over the ground. The absolute values of the lengths of these lines are preferably arranged to be varied in accordance with the altitude of the aircraft, so that a narrow ladder or track is displayed if the aircraft is at a great height and the width of this track increases as the aircraft descends.—*July* 19, 1961.

ULTRASONICS

871,946. July 22, 1959.—SUPERSONIC VIBRATION GENERATOR, Vuma Vyvojovy Ustav pre Mechanizaciu a Automatizaciu, Nove Mesto n/Vahom, Czechoslovakia.

In generators of ultrasonic vibrations with piezo-electric transducers it is advisable to retain underneath the transducer an air bubble in order to reflect the ultrasonic energy from this air cushion and to prevent its radiation downwards. Various means for the formation of this air space have been proposed in the past, which are, however, as a rule not very efficient. A further drawback of present ultrasonic generators is that the electrically insulating liquid which fills the generator space comes into contact with the atmosphere and picks up moisture, thus reducing substantially its disruptive strength. It is an object of this invention to provide an ultrasonic generator with a one way radiating piezo-electric transducer designed so as to remove the above drawbacks. The major advantage of this generator is the hermetic separation of the inner space from the surrounding medium. In the drawing the body of the ultrasonic generator comprises an upper annular



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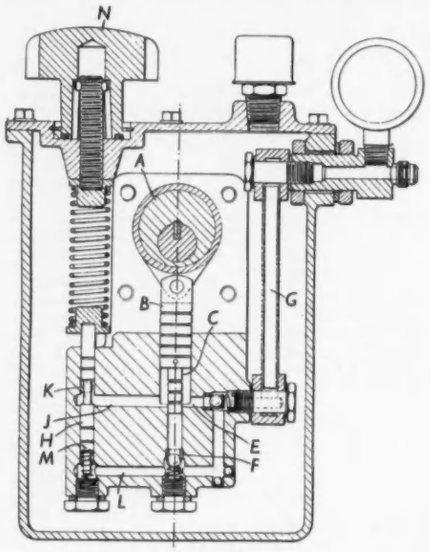
part *A* and a lower cylindrical part *B*, which are connected by bolts *C* and define the inner space of the generator. The diameter of part *B* is smaller than the outer diameter of the annular part *A*. A mechanical resonator *D*, which has a half-wave mode of resonance, is soldered on the inside of the upper annular part *A*. A leading-in insulator *E* is provided at the bottom of the lower cylindrical part. Piezo-electric transducer *F* contacts the resonator and a dish-shaped element *G* is pressed against the metallic coating of the transducer, defining below it an air space, which prevents the unwanted and uneconomic radiation of the ultrasonic energy downwards. The dish-shaped element, and thus also the piezo-electric transducer, are pressed against the resonator by a spring *H* bearing against the leading-in insulator *E*. The high-frequency voltage is supplied to the piezo-electric transducer over the spring *H* and the dish-shaped element *G*. The inner space of the generator is filled with an electrically insulating liquid, which is supplied through the port *J*, closed by a threaded bolt. The liquid level reaches up to the mark *K*. The described construction has the further advantage that the pressure acting upon the piezo-electric transducer with the dish-shaped element does not increase excessively due to expansion of the heated electrically insulating liquid, as an automatic compensation takes place so that for an increased fluid pressure the air pressure inside the dish-shaped element increases equally.—*July* 5, 1961.

HYDRAULIC EQUIPMENT

872,557. June 25, 1958, HYDRAULIC PUMPS, Dowty Equipment of Canada, Ltd., Ajax, Ontario, Canada. (*Inventor : Geoffrey Lindley Harrison.*)

The object of the invention is to provide a simple pump which is capable of delivering liquid up to a

selectable pressure and in which the rate of displacement is considerably reduced when this pressure is attained, so that the liquid is not unduly heated whilst the pump maintains the pressure. The complete pump is enclosed in an oil reservoir and a single drive shaft has an eccentric *A* around which an eccentric ring is located. This ring is connected



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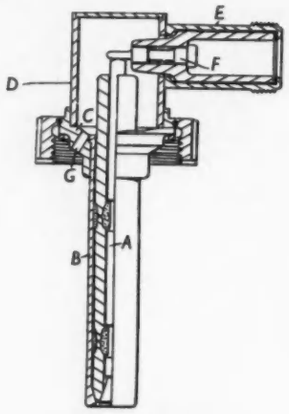
pivotally to one end of a large piston *B* which reciprocates in a cylinder in the block. From the opposite end of the large piston a piston *C* extends into a smaller diameter cylinder. Ports at their upper ends opening into the reservoir form inlets into the cylinders. At the end of each cylinder remote from the eccentric, non-return output ports *E* and *F* are connected through pipe *G* to the output hydraulic pressure connection on the wall of the reservoir. A piston valve in the cylinder block contains a simple piston member *H* having a central single groove. One end of the piston valve projects from the block and is engaged by a helical compression spring which at the upper part is connected to an adjustable screw mechanism. By the groove in the piston valve a port *J* is in connection directly to the output *E* of the large cylinder and the port *K* opens into the reservoir. The arrangement normally is that outlet from the large cylinder feeds into the groove whilst the piston valve closes the port leading back to the reservoir. The end of the piston valve opposite to the spring is exposed through passage *L* to the pressure fluid delivered at the outlet connection of the pump. This pressure normally urges the piston valve to compress the loading spring. A further port *M* is provided to begin to vent fluid at output pressure back to reservoir when the piston valve is moved a sufficient distance against spring compression to cause full by-pass of the output of the large cylinder back to reservoir through port *K*. Pressure adjustment is made by turning the knob *N* on the reservoir with reference to the gauge. When the preselected pressure is reached the valve *H* moves and the output of the large cylinder of piston *B* is fully by-passed in the reservoir whilst the output of the small cylinder of *C* is by-passed wholly or partially through port *M* to maintain the desired pressure. The amount of oil that is pumped at pressure back to reservoir is therefore only the output of the small cylinder and the heat developed is comparatively small. When an increase in pressure is required the whole output of both cylinders is available.—*July* 12, 1961.

AIRCRAFT ENGINEERING

872,814. May 19, 1959.—IMPROVEMENTS IN IGNITERS, K. L. G. Sparking Plugs, Ltd., Putney Vale, London, S.W.15. (*Inventor : George William Shoobert.*)

This invention relates to an igniter for aircraft gas turbines and which has part of the wall of its contact chamber exposed to air pressure in the combustion equipment of the turbine. When in use, the interior of the chamber will be subjected to the air pressure in the combustion equipment which, of course, is above ambient atmospheric pressure and so the insulating properties of the air space surrounding the bare connection will be enhanced when the turbine is running, as compared with constructions in which the connection is surrounded by air at atmospheric pressure. This is an advantage when an aeroplane is flying at a high altitude where the rarefied air of the ambient atmosphere does not provide good insulation around the bare connection. In the embodiment illustrated the igniter is of the surface discharge type and comprises a central electrode *A* surrounded by a tubular ceramic insulator in turn surrounded by an earthing electrode *B*. At its connection end (i.e. the end remote from the discharge end) the insulator projects from the surrounding earthed electrode and the central electrode projects from the insulator. The earthed electrode, at its end, has a flange received within a cup *C*. A cylindrical wall *D* which fits the



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cup surrounds, but is spaced from, the insulator and central electrode of the igniter and at its upper end is sealed by a disc. The cup carries a union nut by which the igniter is mounted on the outer wall of the air casing of a gas turbine. The electrodes and insulator of the igniter then extend through a hole in the corresponding flame tube wall so that the operative (i.e. discharge) end of the igniter is located in the path of fuel projected into the combustion equipment. The wall *D* has a hole in one side from which a projecting tubular member *E* is sealed. The tubular member carries an insulator and contact member *F* which projects into the chamber and is joined to the central electrode of the igniter, there being a bare connection between the connecting member and the central electrode which is contained within and spaced from the walls of the chamber. The base of the cup *C* has one or more holes *G* bored through it so that the interior of the chamber is maintained at the same pressure as that in the air casing of the engine when the turbine is running.—*July* 12, 1961.

STEEL MANUFACTURE

872,718. April 24, 1958.—MANUFACTURE OF STEEL, Demag Aktiengesellschaft, Wolfgang-Reuter-Platz, Duisburg, Germany, and Wilhelm Schmitt, Hansa-Allee 167, Dusseldorf, Germany.

In Siemens-Martin regenerative furnaces hot gases and hot air are normally passed together into the furnace head, and every effort is made to obtain a long flame sweeping across the whole furnace bath. The invention proposes to blow gas under pressure, in the form of fine jets, into the hot stream of air during the melting-down period, and thus to produce a short, intensive, hot flame, whilst in the further course of the steel production, a single low-pressure gas jet is blown into the stream of hot air, thus producing a long flame. This long flame may also be produced by means of an oil burner. It was to be expected that a short and intensive flame would attack the brickwork to a greater extent than a long flame, but experience however showed that this was not so. The design and arrangement of furnace and its nozzles are illustrated by drawings in the specification.—*July* 12, 1961.

LIQUID FUEL BURNERS

869,852. July 3, 1957.—LIQUID FUEL DISCHARGE NOZZLES, Joseph Lucas (Industries), Ltd., Great King Street, in the City of Birmingham, 19. (*Inventor : Sidney Conner Watkins.*)

In conventional liquid fuel discharge nozzles of the swirl type the liquid is supplied tangentially to a conical swirl chamber having a small discharge orifice at its apex. While passing through the swirl chamber a rapid rotary or eddy motion is imparted to the fuel, so causing it to issue from the nozzle in the form of a thin hollow conical film which quickly disintegrates into the condition of a fine mist. To obtain satifactory nebulisation it is necessary to supply the fuel at a sufficiently high rate, and in this condition an axial air core is set up in the liquid in the swirl chamber. When the liquid is supplied at a low rate at which no air core is formed, the issuing jet breaks up into relatively coarse drops, and the resulting fuel-air mixture is unsatisfactory where a high rate of combustion is required. The object of this invention is to provide a nozzle which enables satisfactory nebulisation of the fuel to be obtained over a wide range of rate of supply of the fuel. The nozzle includes a swirl chamber having a discharge orifice at its apex and an axial orifice in its base. There is a cavity into which fuel can flow through the axial orifice from the swirl chamber when no air core exists in the chamber. An air duct in communication with the cavity terminates in a discharge orifice coaxial with the discharge orifice of the swirl chamber. The arrangement is such that at a low rate of fuel supply air-nebulisation of the fuel is effected in the air duct whereas at a high rate of fuel supply, normal swirl-nebulisation occurs. Drawings with the specification show the construction of the nozzle.—*June* 7, 1961.

Catalogues and Brochures

MAX ARC, Ltd., Walton-on-Thames, Surrey.—Leaflet containing technical details of a 0·200 electric arc welder.

INTERNATIONAL COMBUSTION PRODUCTS, Ltd., 19, Woburn Place, London, W.C.1.—Publication No. M614 entitled "Foundry Mechanisation."

ARENS CONTROLS, Ltd., Trowers Way, Holmethorpe, Redhill, Surrey.—Illustrated brochure giving technical details of mechanical remote control systems.

RADIOVISOR PARENT, Ltd., Stanhope Works, High Road, London, S.W.19.—Leaflet describing a photo-electric relay type QT. 60, for industrial control operations.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 2605 dealing with paddle-bladed D fans which are used in dust and fume exhausting.

OLD PARK ENGINEERING, Ltd., Dudley, Worcs.—Illustrated leaflet giving details of the pressure vessels, air receivers and storage tanks the company fabricates for the oil, chemical, gas and atomic energy industries.

FERRANTI, Ltd., Hollinwood, Lancashire.—Brochure describing and illustrating the chief activities of the company during the year 1960-61 under two main headings, electrical engineering and electronics and automation.

PLENTY AND SON, Ltd., Eagle Iron Works, Newbury, Berks.—Leaflet covering, very briefly, the main range of Plenty products—positive displacement rotary pumps, filters for liquids and gases, chemical plant, and mixers. The leaflet has been printed in French, German and English.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Thurs. and Fri., Sept. 21 *and* 22.—Department of Physics, University College of North Wales, Bangor, Joint conference on "Radiospectroscopy of Solids," Guthrie Lecture to be delivered during the conference—"The de Haas-van Alphen Effect and the Electronic Structure of Metals," D. Shoenberg.

Thurs. and Fri., Sept. 28 *and* 29.—ELECTRONICS GROUP : Assembly Room, Town Hall, Leamington Spa, Joint conference on "The Physics of Gas Discharge Devices."

INSTITUTION OF ELECTRICAL ENGINEERS

Wed. to Fri., Sept. 6 *to* 8.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, Conference on "Microwave Measurement Techniques."

INSTITUTION OF MECHANICAL ENGINEERS

Tues. and Wed., Sept. 5 *and* 6.—SCOTTISH GRADUATES' SECTION : Autumn Conference in Scotland.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 5.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Corrosion—Prevention by Cathodic Protection," R. A. Lowe, 7 p.m.

Wed., Sept. 6.—LEICESTER BRANCH : Grand Hotel, Leicester, "Gas in Industry," L. A. Lush, 7.30 p.m.

Tues., Sept. 12.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, Members' Evening, 7.30 p.m.

Wed., Sept. 13.—WESTERN BRANCH : Royal Clarence Hotel, Exeter, Film, "The Hinkley Point Power Station," 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Wed., Sept. 13.—EAST MIDLANDS BRANCH : College of Technology, Ashby Road, Loughborough, One-day conference on "The Application of Instrumentation in Industry with Special Reference to the Problems of the Small Firm," 9.30 a.m.

Advanced Engineering Courses

Mathematical Programming. THE UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. The course is intended for members who are already familiar with the standard linear programming methods. It deals with more advanced techniques, which greatly extend the field to which programming may be applied. It is aimed at operational research workers, production planners and others who are concerned with programming problems. The course runs from Monday to Friday, September 25 to 29. Fee, covering course papers and all residential charges and meals, 35 guineas.

Corrosion Problems in the Electrical Power Industry. Eighth Summer School on Corrosion. BATTERSEA COLLEGE OF TECHNOLOGY, Metallurgy Department, London, S.W.1. The course, which runs from September 25 to 28, 1961, has been arranged in conjunction with the Corrosion Group of the Society of Chemical Industry and will deal with corrosion as it affects each stage in the generation of electrical power. "Introduction," E. C. Potter ; "Furnace-side Corrosion," W. D. Jarvis ; "High Temperature Water-side Corrosion," E. C. Potter ; "Corrosion of Cooling Surfaces," P. J. Gilbert ; "Corrosion of Feedline Surfaces," J. T. Harrison ; "Corrosion of Turbines," M. G. Gemmill ; "Corrosion in Transmission and Distribution," H. G. Masterson ; "Boiler Feedwater," H. J. Fortune. It is hoped to arrange a visit to Central Electricity Research Laboratories, Leatherhead, on Thursday, September 28. Fee £10, inclusive of luncheon, morning and afternoon refreshment.